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THE SOCIETY is the growth of over forty years of achievement and leadership. Its members are engineers and technicians skilled in every branch of motion-picture film production and use, in television, and in the many related arts and sciences. Through the Society they are able to contribute effectively to the technical advance of their industry. The Society was founded in 1916 as the Society of Motion Picture Engineers and was renamed in 1950.

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SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

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Perceptions of Colors in Projected and Televised Pictures

By D. L. MacAdam

Many color photographs are taken in daylight and projected with tungsten lamps. On the other hand, commercial motion pictures made with tungsten studio lamps are almost always projected with arcs that resemble daylight. Color-television receivers produce "white" of daylight quality or even bluer, although most of the scenes televised are tungsten-lighted. Hence the question: "How should a color in one quality of illumination be reproduced for viewing with some other quality?" An investigation undertaken to answer this question will be described, and the results will be discussed.

The simple answer suggested by Von Kries's law of coefficients appears to be only a first approximation. Closer analysis of the behavior of the eye seems to indicate that human color vision is served by at least four, and probably by five or even six, different photosensitive processes, having different spectral sensitivities and different degrees of adaptation to various qualities of illumination.

These findings do not call into question the trichromatic character of color perception, on which color photography and color television are based. Apparently the visual nervous system provides only three channels, capable of handling only three independent responses. But each of these responses appears to be stimulated by a combination of two or more photosensitive processes in the eye.

Although it is generally known that color pictures must be taken with suitable color of illumination, it is usually taken for granted that a good color picture can be viewed or projected with almost any kind of light. To a rough degree of approximation, this is so. But, when the highest quality is sought, it is advisable to remember the song from *Porgy and Bess*, "It Ain't Necessarily So."

If color pictures made outdoors are to give the best results when they are projected with tungsten light, or if color pictures made in a tungsten-lighted studio are to show top quality when projected with carbon-arc light, it will be necessary to at least consider whether the colors projected with tungsten light appear the same as the colors of the same picture projected with an arc. Human eyes are very obliging, and after a few minutes of getting accustomed to the light, the whites and grays and pale colors all appear right, no matter what the color of the projector light. But how about the other colors?

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This problem has been studied by a number of people. The earliest studies used the method of "memory colors," in which the observers first learned to name colors, usually by some systematic and partially numerical system, such as the Munsell or Ostwald. Then they were given a large assortment of colors, one at a time, to name in daylight, and later on they repeated the same task in tungsten light.[1,2] Any changes of names were indications of the failures of the usual assumption — that the light source makes no difference.

More recently, the method of binocular matching has been used.[3–7] With this method the right eye may be made to look at a broad expanse of white illuminated by daylight, while the left eye looks at a white surface illuminated by tungsten light. After a few minutes, all differences fade out — and the two eyes are adapted to the two different lights. Then a small patch of some color is shown to the right eye, and, apparently beside it, by binocular fusion, a second color is shown to the left eye. The observer can adjust one of the colors until the two small patches seem to match. The colors are physically quite different and are the corresponding colors for daylight and tungsten-light adaptation.

A third method has been devised which is called the method of local adaptation, in which both eyes see the same things, but, by unwavering gaze, the right sides of both eyes are adapted to daylight and the left sides to tungsten light. Then, for one second only, the adapting lights are replaced by test colors. In the present work, two observers determined numerous pairs of colors which produced identical perceptions when the observers were adapted to two different chromaticities.

Procedure

Two halves of a colorimeter were filled with different adapting colors. The field subtended 8° at the eyes of the observer. Every 10 sec, for 1 sec only, a test color replaced the adapting color in one half, and an adjustable combination of three primaries replaced the adapting color in the other. The observer saw the complete field with both eyes (natural pupils) at all times. He looked directly at the center of the dividing line, and adjusted the primaries during the adaptation periods, so as to make the two halves of the field appear to match during the brief exhibition of the test and comparison colors.

The colorimeter used for these experiments is shown schematically in Fig. 1. It represents the top view of the wide-field colorimeter previously described.[8] The observer looks at the righthand end. Two vanes have been added to the colorimeter, to block off the light from the three color filters. When the vanes are in the position shown in the upper part of Fig. 1, light from two auxiliary lamps can enter the two integrating spheres. Filters can be placed in the path of the light from the auxiliary lamps so as to produce any pair of adapting colors. The vanes are mounted on rotary solenoids. When current is passed through the solenoids, the vanes are very quickly removed from the main beams of the colorimeter and, as shown in the lower part of Fig. 1, the vanes then intercept the beams from the auxiliary lamps.

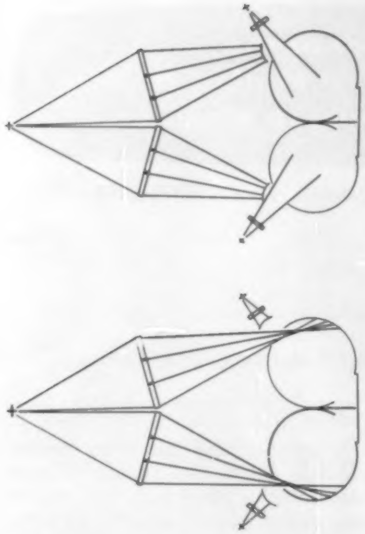

Fig. 1. Schematic diagrams of wide-field binocular colorimeter, showing solenoid-operated vanes for alternating adapting and test colors.

The solenoids are activated, for one sec only, every 10 sec.

During the 9-sec interval, the two halves of the colorimeter field at the center of the righthand end in Fig. 1 are filled with the two adapting colors produced by the auxiliary lamps. During the 1-sec period of activation of the rotary solenoids, these adapting colors are removed and instantly replaced by the colors synthesized by the two halves of the wide-field colorimeter. After a 1-sec exposure of those colors, the adapting colors reappear in the colorimeter field.

The observer sits in front of the colorimeter and gazes fixedly at the center of the dividing line. After a few 10-sec cycles, the observer can notice that the two halves of the field look almost alike during the 9-sec adaptation period. This is true even though one half of the colorimeter field may contain artificial daylight, and the other half of the field may contain light typical of that from tungsten lamps. If the two adapting colors are equally bright, the local adaptation is such that after a few cycles the observer notices little difference between the two halves of the colorimeter field. Under such circumstances, if two physically identical colors are exhibited in the two halves of the colorimeter field during the 1-sec exposures, they will appear greatly different.

An apparent match can be obtained by readjusting the color of one half of the field. This can be done conveniently by use of the remote controls of the wide-field colorimeter. The amounts of the primaries found to produce the equivalent color in the adjustable half of the colorimeter can be recorded automatically. The observer can sit undisturbed in front of the colorimeter and can maintain his attention and gaze fixed on the center of the dividing line, while he adjusts and records and readjusts and records three or more apparent matches. The corresponding portions of his eyes thus remain adapted to the two qualities of light which are present in the colorimeter field for 9 out of every 10 sec.

Each observer matched each test color three or more times, as in ordinary colorimetry, without the intervention of the adapting colors; then the alternation of adaptation and test colors was begun. The observer gazed fixedly at the center line and readjusted the comparison color in the left half of the field, so as to make it appear identical to the color in the right half of the field. Usually, this process of matching required a dozen or more alternations of the adaptation and test colors. The observer would notice the kind and the extent of the apparent color difference during each flash. Then, during the subsequent 9-sec adaptation period, he adjusted the remote controls of the colorimeter in the direction and amount which he judged would improve the color match. He verified his success in the succeeding flash and made further adjustments and observations as required.

When the observer was satisfied, he pressed the recording button. He then

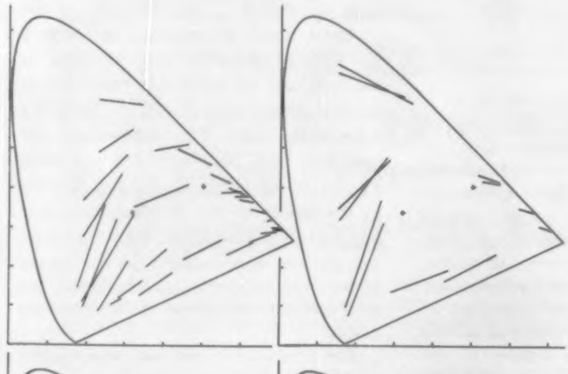

Fig. 2. Top: Corresponding colors for Observer DLM (left), EJB (right), when adapted to artificial daylight and incandescent tungsten light (shown by crosses). Bottom: Corresponding colors (for observers as specified above) for adaptations to desaturated green and pink light (shown by crosses).

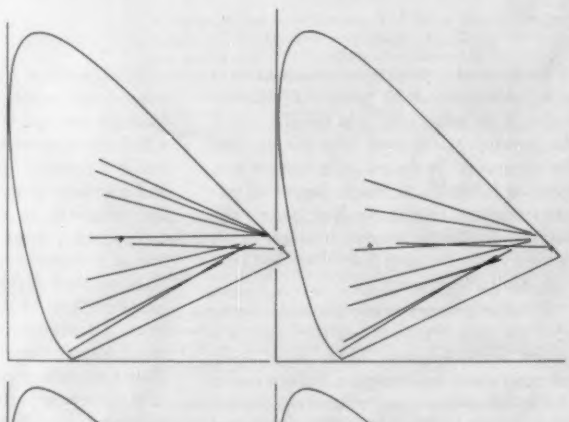

Fig. 3. Top: Corresponding colors for adaptations to red and artificial daylight. Bottom: Corresponding colors for adaptations to desaturated greenish-yellow and artificial daylight.

disturbed all of the colorimeter controls, so as to destroy the color match. He repeated the matching and recording process three or more times. During all these operations, he kept his gaze fixed rigidly on the center of the dividing line. This maintained almost complete adaptation, so that the artificial daylight in the left half of the field and the tungsten light in the right half of the field continued to appear almost exactly matched.

This process requires a very high order of concentration and freedom from interruption. Frequently, the observer has the impression that he is almost in a state of hypnosis. Frequently, also, he has the feeling that he can complete the process of adaptation by an effort of will, so that, during the last second or two of each period of adaptation, he can quite completely eliminate all appearance of color difference between the daylight and the tungsten-lighted halves of the field. When he has such an impression, he can be quite sure of the color match, or color difference, which he notices during the 1-sec flash of the test colors.

After some practice, observers become quite proficient at this type of color matching.

Results

The results of such experiments, for adaptation to tungsten light and to daylight, for two observers, are shown at the top of Fig. 2. The tristimulus values and chromaticity coordinates for these colors are given in Table I. The color indicated by the righthand end of each line in Fig. 2 has the same appearance for the part of the eye adapted to tungsten light as does the color which is indicated by the left-hand end of the line, when that second color is seen by a portion of the eye adapted to daylight. These lines are quite long in most cases. The lengths and directions of the lines connecting corresponding colors are very similar for the two observers.

The results of similar experiments, employing a green and a pink adapting color, are given in Table II, and are shown in the lower half of Fig. 2. The results of similar experiments for adaptations to red and to artificial-daylight qualities are given in Table III, and are shown in the upper half of Fig. 3. Corresponding colors found for adaptations to a greenish-yellow and an artificial daylight are specified in Table IV, and are shown in the lower half of Fig. 3. Results for blue compared with daylight adaptation are given in Table V, and are plotted in the upper half of Fig. 4, and results for green compared with daylight adaptation are given in Table VI, and are plotted in the lower half of Fig. 4. The colors to which the corresponding portions of the eyes were adapted are specified in Table VII and are shown by crosses in Figs. 2–4.

The Von Kries Coefficient Law

Von Kries[9] suggested that such adaptation effects might be accounted for by assuming three types of visual receptors, the responses of which would be differently affected, but the spectral sensitivities of which would not be influenced by those adaptations. If colorimetric data could be expressed in terms of primaries corresponding to such receptors, then the tristimulus values of all colors for one condition of adaptation would bear fixed ratios to the corresponding tristimulus values for the visually equivalent colors observed under another condition of adaptation. This is the Von Kries coefficient law.[10–13]

Using estimates of the primaries which correspond to the receptors, as proposed by Helson, Judd and Warren,[2] Wyszecki[14] described a graphical method for predicting the corresponding colors for any two prescribed conditions of adaptation. This prediction method was adapted to electronic computing machines and was applied to the present data.

It is not realistic to assume that adaptation to the two adapting colors is complete. In the present work, the values of $R = Y$, $G = -0.46X + 1.36Y + 0.10Z$, $V = Z$ were computed for all colors. Then, for each pair of adaptations and for each observer, the average ratios R'/R, G'/G, V'/V were computed and used as adaptation coefficients. Cases in which the denominator was zero, or in which it had only one significant figure, were omitted from the averages. The values of R, G, V, computed from the observed X, Y, Z, were multiplied by the appropriate adaptation coefficient (listed in Table VIII) to obtain the predicted values of R', G', V'. The values of R', G', V', computed from the observed X', Y', Z', were divided by the adaptation coefficients, to obtain the predicted values of R, G, V. The predicted values of X, Y, Z (or X', Y', Z') were computed from the predicted values of R, G, V (or R', G', V') as follows: $X = (1.36R - G + 0.1V)/0.46$, $Y = R$, $Z = V$.

The chromaticities of the predictions are compared with those observed, for daylight and tungsten-light adaptations in Fig. 5. The predictions are compared with the observations for the pink and the green adaptations in Fig. 6. Although

Table I. Corresponding Colors.

Tungsten-light adaptation					Daylight adaptation				
X	Y (ft-L)	Z	x	y	X'	Y' (ft-L)	Z'	x'	y'
				Observer DLM					
21.1*	21.8	22.9	0.3207*	0.3316	29.2	16.8	110.9	0.1858	0.1071
54.7	48.2	14.6	.4656	.4099	30.7	33.3	31.0	.3230	.3509
150.4	70.9	0.9	.6770	.3192	100.3	47.4	3.6	.6629	.3133
149.7	62.1	0.0	.7070	.2930	99.5	42.7	3.6	.6827	.2927
147.3	62.5	1.0	.6987	.2965	111.3	48.9	4.6	.6754	.2967
149.7	76.6	1.5	.6572	.3364	89.5	49.9	5.2	.6188	.3454
142.8	82.4	2.3	.6275	.3623	93.8	58.7	6.7	.5893	.3685
144.2	90.6	3.1	.6061	.3809	90.4	64.6	7.0	.5581	.3986
68.5	59.6	3.1	.5221	.4541	37.1	42.5	6.2	.4327	.4955
66.3	47.3	2.0	.5737	.4092	42.8	35.9	4.4	.5150	.4320
27.2	29.8	1.9	.4622	.5063	17.2	22.8	6.3	.3714	.4925
67.4	43.7	1.6	.5983	.3877	52.6	37.8	7.6	.5368	.3853
65.0	40.0	1.3	.6114	.3763	47.2	30.7	3.7	.5786	.3760
15.3	27.1	2.1	.3441	.6093	8.1	22.1	5.3	.2272	.6228
16.8	25.0	16.0	.2899	.4327	16.1	23.2	46.5	.1876	.2703
15.0	25.7	6.2	.3196	.5477	10.6	22.8	13.5	.2263	.4864
15.9	25.1	11.3	.3034	.4800	11.4	22.3	27.2	.1870	.3662
18.1	26.8	26.1	.2549	.3772	23.4	19.3	92.9	.1729	.1424
16.4	19.1	23.7	.2773	.3226	29.0	14.3	112.0	.1865	.0921
14.9	10.4	22.9	.3089	.2162	21.9	8.0	66.4	.2275	.0836
27.4	16.5	23.4	.4079	.2446	26.6	15.0	34.1	.3516	.1981
16.3	7.9	23.4	.3432	.1652	17.0	7.1	36.7	.2795	.1166
38.2	15.6	80.2	.2847	.1167	32.5	12.8	80.6	.2579	.1019
74.0	32.5	68.4	.4230	.1861	70.6	25.9	116.2	.3318	.1219
70.1	34.1	23.4	.5493	.2675	52.3	25.5	39.6	.4456	.2168
138.4	58.1	22.9	.6308	.2646	111.0	45.4	42.7	.5576	.2281
136.6	57.0	9.5	.6726	.2805	104.8	43.9	20.8	.6183	.2591
151.0	63.0	5.7	.6873	.2869	105.3	46.1	12.3	.6431	.2815
				Observer EJB					
100.6	42.2	0.0	0.7040	0.2956	69.0	31.4	2.9	0.6677	0.3041
103.9	53.5	1.0	.6558	.3376	75.2	42.8	5.1	.6107	.3477
48.2	34.6	1.9	.5690	.4085	42.7	34.1	5.2	.5216	.4155
54.1	39.1	1.7	.5701	.4123	33.8	28.9	4.1	.5060	.4322
12.5	22.4	1.7	.3408	.6120	4.0	20.2	4.1	.1410	.7154
11.0	21.7	1.7	.3203	.6299	3.7	18.2	4.3	.1416	.6941
13.8	22.9	11.8	.2848	.4714	7.9	18.2	26.1	.1509	.3486
11.9	20.5	10.8	.2759	.4746	8.4	17.6	29.5	.1518	.3166
16.8	23.9	23.2	.2632	.3733	30.4	17.5	130.6	.1701	.0979
15.2	17.7	23.1	.2709	.3158	30.8	12.8	129.7	.1775	.0739
57.1	25.5	52.9	.4214	.1880	58.6	28.5	120.4	.2824	.1372
52.1	21.6	19.3	.5597	.2323	41.5	15.9	41.2	.4206	.1616

* The chromaticity coordinates x,y, x',y' listed in Tables I to VI were computed from the original tristimulus values, X, Y, Z, X', Y', Z' before the latter were rounded off to one decimal place, as listed in Tables I to VI. There are, for this reason, some slight numerical inconsistencies between the tabulated tristimulus values and the chromaticity coordinates. The experimental uncertainties are not more than a few units in the next to the last digit listed. In some cases, such as tristimulus values less than 10, the uncertainties are confined to the last digit.

Table II. Corresponding Colors.

Green adaptation					Pink adaptation				
X	Y (ft-L)	Z	x	y	X'	Y' (ft-L)	Z'	x'	y'
				Observer DLM					
78.6	35.6	0.3	0.6862	0.3113	83.2	34.4	0.9	0.7019	0.2905
100.0	81.6	3.7	.5397	.4405	108.9	68.7	8.6	.5849	.3691
70.6	90.3	5.6	.4241	.5424	95.8	78.3	11.5	.5164	.4219
39.1	76.9	5.5	.3219	.6325	64.9	64.1	8.3	.4726	.4670
27.7	73.7	5.7	.2588	.6881	56.0	59.3	7.9	.4547	.4813
27.9	75.1	8.9	.2492	.6716	53.1	59.4	11.4	.4285	.4798
28.3	72.0	11.3	.2530	.6456	54.1	58.4	16.1	.4205	.4542
28.9	70.0	18.4	.2463	.5966	55.3	59.9	27.2	.3883	.4206
19.6	45.3	16.5	.2408	.5561	39.8	40.7	26.0	.3735	.3821
15.7	23.0	39.1	.2015	.2958	34.4	16.9	80.0	.2622	.1287
50.5	37.0	38.7	.3997	.2935	72.9	35.2	79.9	.3879	.1872
42.0	19.8	14.0	.5548	.2609	45.1	17.6	19.8	.5470	.2136
92.3	75.0	3.4	.5411	.4393	102.9	64.5	5.4	.5957	.3733
88.8	58.5	23.1	.5215	.3432	112.0	59.6	36.0	.5394	.2870
81.0	86.5	19.5	.4333	.4625	114.0	82.0	32.2	.4996	.3593
29.4	25.7	37.9	.3165	.2760	50.0	25.2	73.7	.3356	.1694
76.1	65.2	22.9	.4633	.3971	99.4	62.1	36.7	.5014	.3133
				Observer EJB					
102.7	83.3	3.7	0.5413	0.4391	125.7	77.2	7.2	0.5983	0.3677
83.0	99.3	5.9	.4409	.5276	111.2	88.6	8.0	.5350	.4264
48.1	88.1	6.2	.3379	.6184	71.9	73.1	7.7	.4705	.4790
26.1	72.5	5.6	.2504	.6955	60.0	67.0	8.0	.4445	.4964
27.5	74.5	9.7	.2463	.6671	58.1	68.0	12.2	.4200	.4915
27.5	75.5	13.3	.2365	.6489	57.4	65.4	18.4	.4067	.4630
28.2	71.8	20.8	.2334	.5941	60.9	66.3	35.5	.3743	.4072
20.2	49.0	20.2	.2258	.5484	42.2	41.6	26.1	.3839	.3784
16.5	22.3	44.4	.1985	.2675	27.6	15.7	32.6	.3633	.2074
60.6	40.7	48.9	.4033	.2709	68.7	31.2	53.0	.4491	.2043
45.8	21.8	16.0	.5483	.2605	46.3	19.4	17.3	.5577	.2345
77.6	35.4	0.3	.6850	.3124	88.3	36.9	1.9	.6947	.2903
106.6	84.5	3.7	.5472	.4339	118.3	73.4	6.3	.5973	.3706
82.8	100.0	6.0	.4383	.5298	101.3	80.8	8.4	.5316	.4243
25.7	70.0	5.4	.2545	.6919	61.6	64.4	8.0	.4596	.4804
115.8	107.1	24.9	.4676	.4321	145.7	95.8	42.1	.5137	.3377
99.9	63.3	28.9	.5199	.3296	113.6	57.4	48.8	.5168	.2611
38.6	32.0	47.1	.3275	.2723	55.4	29.0	52.2	.4055	.2125
84.3	64.0	23.6	.4902	.3725	108.2	62.2	38.2	.5186	.2982

the predictions are generally similar to the results of the observations, there seem to be significantly large systematic discrepancies. These stimulated search for a more successful formula.

Least-Squares Adaptation of Coefficient Law

Brewer[13] proposed a least-squares method by which the most accurate prediction formula consistent with the trireceptor coefficient law can be derived from the results of adaptation experiments. Brewer's method was applied to the present data, with results which are indicated in Figs. 7–10. The prediction formulas used are listed in Table IX. If judged only on a numerical or geometrical basis, the accuracy of prediction is distinctly better than for the formulas based on the Judd primaries, but when the predictions are considered to represent colors, they present some highly objectionable anomalies, such as the qualitatively very wrong predictions indicated in the red corner of the chromaticity diagrams in the upper half of Fig. 7. These are attributable to the assumption, dictated by the least-squares method, of primaries at highly implausible locations in the chromaticity diagram. The most usual cause for anomalies was a red primary distinctly within the spectrum locus.

Table III. Corresponding Colors.

Red adaptation					Daylight adaptation				
X	Y (ft-L)	Z	x	y	X'	Y' (ft-L)	Z'	x'	y'
				Observer DLM					
521.1	215.3	11.9	0.6964	0.2878	128.9	119.1	149.2	0.3246	0.2997
124.6	59.0	0.7	.6763	.3201	21.2	45.6	22.0	.2386	.5137
105.7	49.6	0.5	.6783	.3183	17.1	36.2	21.3	.2292	.4854
67.1	32.0	1.0	.6702	.3199	13.2	22.4	17.1	.2502	.4249
57.8	28.8	2.6	.6476	.3234	15.7	22.9	34.5	.2146	.3131
70.9	35.0	11.5	.6041	.2979	25.0	25.1	71.0	.2066	.2075
53.7	24.7	4.8	.6453	.2969	20.3	14.2	72.0	.1907	.1333
22.3	10.0	7.4	.5614	.2519	18.3	6.1	77.7	.1791	.0593
11.6	5.5	1.6	.6206	.2942	12.3	1.7	62.9	.1598	.0216
				Observer EJB					
511.8	211.7	5.2	0.7023	0.2905	130.9	127.5	165.7	0.3087	0.3006
126.2	63.5	1.4	.6602	.3324	18.2	37.0	25.1	.2265	.4604
79.7	38.2	1.2	.6690	.3208	14.0	23.6	23.3	.2299	.3872
86.1	41.1	3.9	.6568	.3137	17.1	24.1	44.2	.1999	.2825
99.5	46.2	5.7	.6574	.3050	25.3	24.7	82.1	.1916	.1867
71.6	31.8	19.3	.5833	.2595	20.4	15.6	77.0	.1807	.1382
34.7	16.1	6.1	.6097	.2823	21.0	6.0	94.4	.1733	.0495
18.1	8.4	4.9	.5745	.2681	17.5	2.5	86.7	.1639	.0236

The locations of the primaries found by Brewer's least-squares method, when applied to the experimental results given in Tables I, II and IV, are indicated by the circles in Figs. 7–10, and are specified in Table X. The small inset diagrams show the locations of primaries remote from the chromaticity diagram. The significance of primaries below the x-axis has been discussed by Wyszecki[15] and Nyberg.[16]

Anomalies of prediction, such as are indicated in the upper half of Fig. 7, can be avoided only by confining the primaries to certain regions of the chromaticity diagram, in accordance with criteria discussed by Nyberg.[16]

Brewer's least-squares method gives nonequivalent prediction formulas, depending on which adaptation of a pair is taken for the initial data and which is the adaptation for which the predictions are sought. The sets of fundamental responses which can be computed from the prediction formulas, in the manner described by Brewer,[13] are different, depending on which one of the two sets of prediction formulas is used. The sets of fundamental responses (primaries) corresponding to the direction of prediction indicated in Figs. 7–10, are shown by circles on the main diagrams and also in smaller-scale inset diagrams. The two nonequivalent sets of prediction formulas found in each case are analogous to the two different formulas obtained in the statistical analysis of supposedly linearly related data (a,b), depending on whether the regression of b on a, or the regression of a on b, is taken. Guided by that analogy, Morrissey has found a method by which a single set of prediction formulas, based on the trireceptor coefficient law, can be obtained.* The mutually reciprocal forms of those formulas are equally appropriate for prediction of the corresponding colors for either of any pair of adaptations.

Those formulas are not optimum for either direction of prediction. They are, however, superior to the formulas which would be obtained by inverting the optimum formulas (obtained by Brewer's least-squares method) in an attempt to predict colors in the direction opposite to that for which the formulas are optimum.

Morrissey's formulas have been applied to the data in Tables I, II and IV. The predictions have all the failings of those given by Brewer's method: large, apparently systematic discrepancies from the observed results, fundamental responses which violate Nyberg's criteria and therefore result in qualitatively implausible predictions, and occasionally solutions for fundamental responses involving complex numbers. Brewer[13] mentioned the occurrence of such solutions, examples of which are noted in Figs. 7, 9 and 10. Although application of weights

*J. H. Morrissey, private communication.

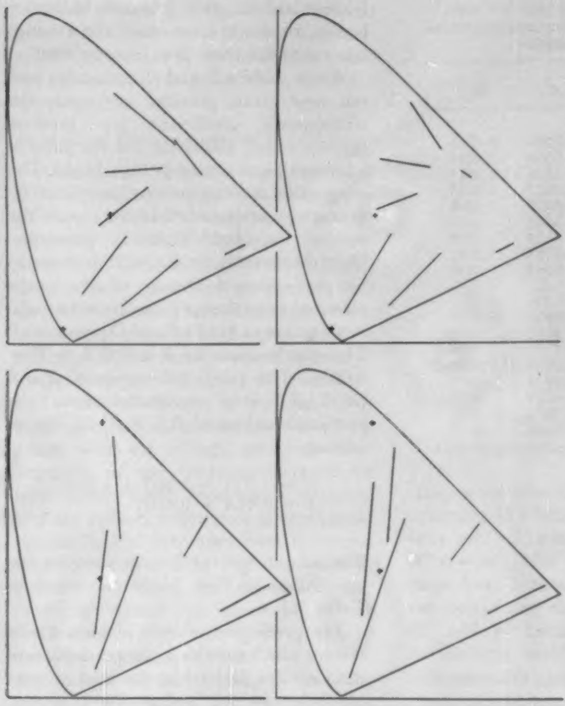

Fig. 4. Top: Corresponding colors for adaptations to blue and artificial light. Bottom: Corresponding colors for adaptations to green and artificial daylight.

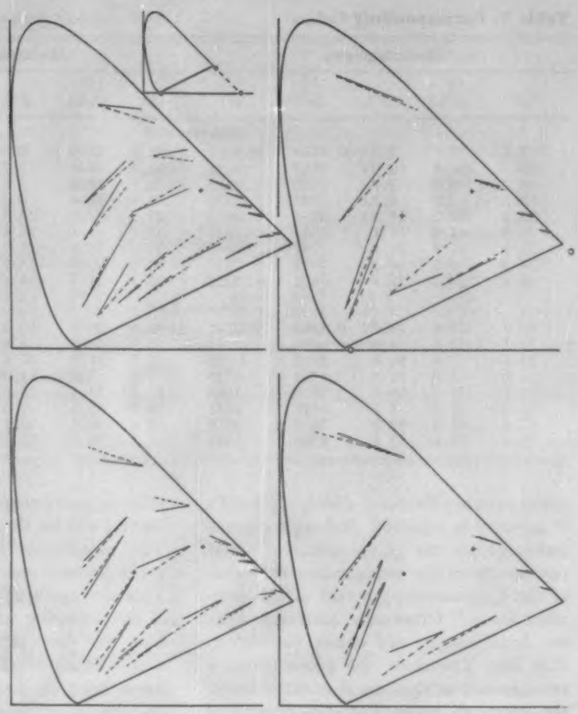

Fig. 5. Comparisons of observed (solid lines) and predicted (dashed lines) corresponding colors. Predictions based on Judd-Wyszecki formulation of Von Kries's coefficient law. Left, Observer DLM; right, Observer EJB. Top: Predictions of colors perceived with adaptation to incandescent tungsten light, corresponding to colors actually observed with adaptation to daylight. Bottom: predictions of colors perceived with daylight adaptation, corresponding to colors actually observed with adaptation to incandescent tungsten light. Fundamental responses (primaries) assumed for Judd-Wyszecki prediction formula are indicated by circles in small-inset chromaticity diagram. Fundamental response chromaticities P and T are also indicated in diagram at upper right.

to the data to give optimum fit in an approximately uniform chromaticity-scale diagram* eliminated the complex solutions indicated in Fig. 7 (compare Fig. 8), it did not have a similarly fortunate result in the case represented in Fig. 9. Since there was little else to recommend the uniform chromaticity-scale weighting, the extra steps of computation required were omitted in the last case (represented by Fig. 10).

Revised "Green" Primary

Objectionable anomalies, such as those shown in the red corners of some of the chromaticity diagrams in Figs. 7–10, can be eliminated only by confining the primaries to certain positions on, or outside, the spectrum locus. Judd's primaries fulfill those requirements. The locations of the blue and the red primaries derived by the least-squares method are generally in agreement with Judd's P and T primaries. According to the least-squares determinations, the coordinates of the

* For this purpose, the sum $U+V+W+U'+V'+W' = X+X'+15(Y+Y')+3(Z+Z')$ was computed for each pair of corresponding colors. The reciprocal of that sum was then used as the weight by which each of the tristimulus values X,Y,Z,X',Y',Z' was multiplied before Brewer's and Morrissey's methods were applied. In effect, this placed the average, or additive mixture, of each pair of corresponding colors on the unit plane and approximately minimized the squares of the deviations of the predicted chromaticities in the uniform chromaticity-scale diagram.

Table IV. Corresponding Colors.

Greenish-yellow adaptation					Daylight adaptation				
X	Y (ft-L)	Z	x	y	X'	Y' (ft-L)	Z'	x'	y'
Observer DLM									
25.8	74.9	8.0	0.2376	0.6888	29.4	73.1	22.9	0.2347	0.5828
69.0	92.4	8.6	.4059	.5437	64.5	86.0	20.9	.3763	.5016
110.1	108.4	8.5	.4851	.4775	102.0	100.1	22.3	.4546	.4460
143.5	115.3	8.1	.5377	.4318	132.0	108.6	23.2	.5004	.4117
138.6	76.6	6.3	.6255	.3460	113.9	66.0	20.3	.5690	.3298
115.3	47.4	7.6	.6773	.2783	81.4	32.7	19.1	.6113	.2456
61.9	24.9	13.3	.6182	.2490	42.6	15.8	33.0	.4658	.1734
4.6	3.6	13.2	.2136	.1690	10.5	2.8	41.2	.1921	.0513
37.0	41.0	16.9	.3900	.4316	37.0	35.6	38.6	.3326	.3200
14.5	27.9	21.8	.2263	.4346	19.7	23.9	51.3	.2073	.2517
20.8	55.3	15.2	.2279	.6055	21.3	43.3	33.8	.2165	.4398
18.8	54.2	6.4	.2369	.6828	18.4	45.7	19.0	.2214	.5500
Observer EJB									
73.3	30.1	5.8	0.6716	0.2755	74.2	30.1	16.8	0.6126	0.2489
36.4	14.7	6.6	.6302	.2550	37.5	15.0	16.5	.5441	.2170
39.7	16.4	12.5	.5790	.2392	40.3	15.2	33.2	.4543	.1714
9.2	5.4	40.2	.1687	.0982	12.3	2.3	51.1	.1877	.3543
17.4	44.7	15.3	.2246	.5775	19.7	40.5	34.9	.2069	.4263
23.9	66.6	12.4	.2326	.6467	24.5	61.8	23.6	.2228	.5627
99.1	98.9	13.1	.4694	.4685	93.9	90.9	23.3	.4511	.4369
12.1	10.1	13.9	.5143	.4268	112.3	92.0	23.0	.4940	.4048
58.8	82.2	13.1	.3813	.5336	57.7	76.0	23.0	.3684	.4847
107.9	63.5	9.5	.5962	.3510	100.8	58.6	17.4	.5699	.3312
34.3	37.1	20.1	.3749	.4057	31.9	30.6	36.1	.3235	.3102

Table V. Corresponding Colors.

Blue adaptation					Daylight adaptation				
X	Y (ft-L)	Z	x	y	X'	Y' (ft-L)	Z'	x'	y'
				Observer DLM					
22.8	27.1	2.5	0.4349	0.5169	45.6	37.8	6.0	0.5103	0.4228
55.7	58.8	10.9	.4442	.4691	90.3	75.1	12.9	.5064	.4214
64.2	26.4	2.7	.6875	.2833	76.8	31.6	3.9	.6836	.2814
18.8	43.1	5.7	.2783	.6379	53.8	61.4	6.3	.4427	.5053
25.0	43.2	31.3	.2514	.4344	52.5	57.0	19.3	.4073	.4426
35.6	44.4	71.1	.2358	.2939	59.1	63.4	36.4	.3721	.3989
35.0	11.0	71.1	.2991	.0939	35.2	16.6	27.2	.4454	.2100
14.2	9.1	50.1	.1931	.1237	13.0	11.4	17.3	.3118	.2741
58.9	23.2	22.7	.5622	.2212	78.7	31.7	16.6	.6195	.2496
				Observer EJB					
65.5	25.8	24.0	0.5680	0.2241	72.6	29.5	16.2	0.6137	0.2495
57.5	23.6	4.9	.6688	.2741	68.9	28.6	4.4	.6762	.2810
23.6	7.4	50.0	.2919	.0912	21.7	11.5	17.1	.4320	.2288
12.0	5.0	51.3	.1758	.0730	8.4	7.8	11.7	.3013	.2802
30.5	53.7	30.4	.2662	.4683	52.4	57.4	20.1	.4035	.4419
32.8	58.3	4.1	.3451	.6121	48.9	55.3	9.3	.4309	.4873
37.6	49.2	58.8	.2585	.3378	54.4	56.0	37.6	.3676	.3785
78.6	72.0	13.8	.4781	.4382	85.8	70.7	12.8	.5068	.4177

green primary fluctuate widely. If Judd's P primary is adopted, Nyberg's criteria indicate that the green primary should not be above the straight-line extension of the long-wavelength end of the spectrum locus.[16] Chromatic confusion lines for deuteranopes are nearly parallel to that line. Therefore, the green primary must be on, or close to, that extension of the spectrum locus. For that reason, of the green primaries indicated by the least-squares method, only those close to that line were included in an average which was taken to determine a green primary more consistent with the experimental results than Judd's D primary. The coordinates adopted for the new green primary were $x = 1.75, y = -0.75$. This average was computed, and most of the following analysis was begun before the case represented in Fig. 10 was computed. This now appears to have been a fortunate circumstance. Inclusion of the green primaries indicated in Fig. 10 would have made the average less successful than that just specified.

When Judd's P and T primaries and the new green primary are used, the trichromatic coefficient law predicts corresponding colors for the six pairs of adaptations, as shown in Figs. 11–16. The adaptation coefficients were computed by averaging, as described in the case of the use of the Judd-Wyszecki primaries. Only the formula for R and R' is changed by the assumed change of the green primary, since that primary is on the same straight line as Judd's P and D primaries.[17] The new formula for R is $0.43X + Y - 0.093Z$. The predicted values of X,Y,Z (X',Y',Z') were computed from the predicted values of $R,G,V(R',G',V')$, as follows:

$$X = 1.30R - 0.95G + 0.216Y,$$
$$Y = 0.44R + 0.41G,$$
$$Z = V.$$

The adaptation coefficients used for the predictions in Figs. 11–16 are listed in Table XI.

The predictions shown in Figs. 11–16 are not much inferior to the predictions of the formulas derived by the least-squares

Fig. 6. Comparisons of observed and predicted corresponding colors for adaptations to desaturated green and pink light (shown by crosses). Top: Judd-Wyszecki predictions of colors for adaptations to pink. Bottom: Predictions of colors for adaptations to green.

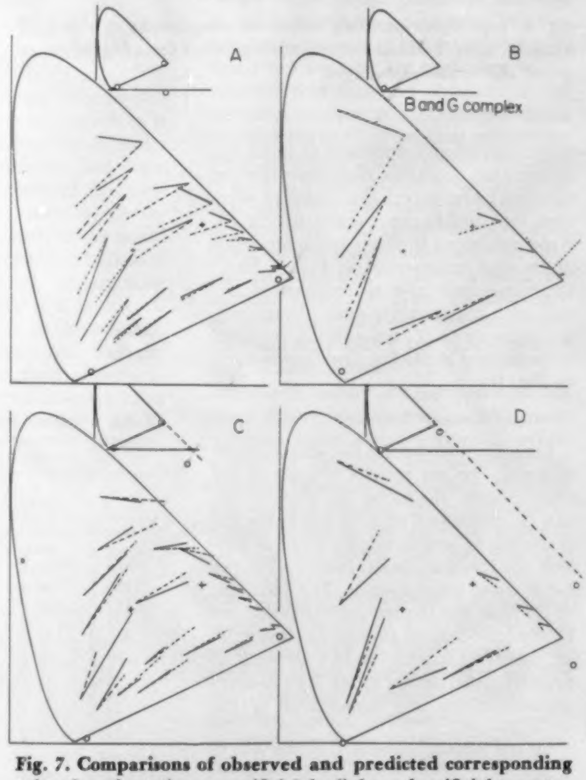

Fig. 7. Comparisons of observed and predicted corresponding colors for adaptations to artificial daylight and artificial tungsten light. Left, Observer DLM; right, Observer EJB. Predictions based on Brewer's least-squares method applied directly to CIE tristimulus values of observed colors. Fundamental responses (primaries) deduced from prediction formulas are indicated by circles, both in main diagrams and in small-inset diagrams. Top: Predictions of colors for adaptation to daylight. Bottom: Predictions of colors for adaptation to tungsten light.

method, shown in Figs. 7–10. On the other hand, the new formulas eliminate all the anomalies of the kind that make the least-squares prediction formulas unacceptable.

Analysis of Discrepancies of Predictions

Although the formulas based on the P and T primaries and the new green primary predict corresponding colors generally like those observed, there remain clear indications of systematic discrepancies between the predictions and the observations. These discrepancies are of the same kind for both observers. It is doubtful if any further modifications of the primaries can eliminate the systematic and consistent failures of the trireceptor coefficient law. This fact, considered together with the failings, noted as characteristic of the formulas derived by both Brewer's and Morrissey's methods, and the radical differences of the fundamental "green" responses found in several cases, as indicated in Fig. 17, seem to call into question the validity of the "coefficient law" on which all of the predictions in Figs. 5–16 were based. In the following analysis, that "law" will be used to approximate the major, first-order effects of adaptation, but the possibility of systematic discrepancies from the predictions of that law will be investigated.

The adequacy of trichromatic colorimeters to match all the colors employed in this investigation indicates that only three color responses are transmitted independently to the portions of the nervous system responsible for the perception of color. Recent studies have indicated that four or more photosensitive processes, with different spectral sensitivities, may be involved in the initial stage of color vision.[18]

If we examine the hypothesis of four such processes contributing to three responses, we would have for the CIE tristimulus values,

$$\begin{aligned} X &= b_{11}(R+c_1J) + b_{12}(G+c_2J) + b_{13}(V+c_3J),\\ Y &= b_{21}(R+c_1J) + b_{22}(G+c_2J) + b_{23}(V+c_3J), \qquad (1)\\ Z &= b_{31}(R+c_1J) + b_{32}(G+c_2J) + b_{33}(V+c_3J). \end{aligned}$$

In these equations, b_{11}, b_{21}, b_{31} are CIE tristimulus values indicative of the chromaticity of one of the fundamental color responses. That response is stimulated primarily to the extent measured by R. But it is also stimulated to the extent measured by c_1J, corresponding to the contamination of the R process by the fourth (J) process. Similarly, b_{12}, b_{22}, b_{32} indicate the chromaticity of the second fundamental color response, which is stimulated to the extent $G + c_2J$. The second term of the last expression measures the contamination of the G process by the J process. Finally, b_{13}, b_{23}, b_{33} indicate the chromaticity of the third fundamental color response. It is stimulated to the extent $V + c_3J$, the second term of which measures the contamination of the V process by the J process.

Hunt discusses the possible rôle of a fourth adapting process, and formulated the necessary condition for preservation of metameric matches with different adaptations.[5] In the present analysis,

Table VI. Corresponding Colors.

Green adaptation					Daylight adaptation				
X	Y (ft-L)	Z	x	y	X'	Y' (ft-L)	Z'	x'	y'
				Observer DLM					
107.0	95.0	5.2	0.5162	0.4585	102.3	79.9	41.1	0.4579	0.3580
24.5	59.5	5.4	.2744	.6649	40.5	56.1	41.9	.2925	.4049
13.9	23.0	17.1	.2579	.4259	25.0	17.8	67.8	.2258	.1612
7.6	8.0	6.5	.3420	.3627	17.2	5.3	53.0	.2279	.0701
127.3	53.8	5.9	.6807	.2879	87.8	35.1	36.7	.5503	.2199
				Observer EJB					
93.1	38.8	2.0	0.6951	0.2896	71.8	28.4	31.2	0.5465	0.2159
5.2	7.6	3.7	.3161	.4598	19.2	4.3	66.7	.2127	.0479
12.7	28.1	10.2	.2487	.5510	26.1	24.3	66.8	.2228	.2075
23.6	49.7	4.5	.3030	.6390	33.2	45.7	36.9	.2870	.3948
93.3	79.2	5.4	.5244	.4450	85.7	66.5	37.1	.4527	.3515

Table VII. Adaptation Colors.

Table	Columns	X	Y (ft-L)	Z	x	y
I	1–5	57.4	46.2	11.7	0.4976	0.4006
I	6–10	42.3	44.8	45.4	.3194	.3379
II	1–5	103.0	121.0	24.0	.4155	.4879
II	6–10	138.8	97.2	41.8	.4997	.3498
III	1–5	277.0	112.2	0.0	.7116	.2883
III	6–10	116.7	123.5	153.7	.2963	.3134
IV	1–5	131.9	206.9	76.2	.3178	.4986
IV	6–10	129.5	164.2	195.5	.2647	.3356
V	1–5	57.2	30.2	330.0	.1371	.0724
V	6–10	63.1	76.1	95.7	.2686	.3239
VI	1–5	50.0	145.0	11.5	.2457	.6989
VI	6–10	141.6	152.0	195.8	.2894	.3107

Table VIII. Adaptation Coefficients.

Figure	Observer	$[R'/R]_{AV}$	$[G'/G]_{AV}$	$[V'/V]_{AV}$
5	DLM	0.77	0.87	2.45
5	EJB	0.83	0.98	3.08
6	DLM	0.88	0.68	1.68
6	EJB	0.88	0.67	1.39

Table IX. Least-Squares Prediction Formulas.

Figure	$X^*_{\text{predicted}} =$	$Y^*_{\text{predicted}} =$	$Z^*_{\text{predicted}} =$
7a	$0.757X-0.158Y+0.264Z$	$-0.023X+0.767Y+0.041Z$	$-0.326X+0.701Y+1.692Z$
7b	$0.705X-0.023Y+0.445Z$	$-0.005X+0.802Y+0.083Z$	$-0.529X+0.938Y+2.976Z$
7c	$1.226X+0.472Y-0.216Z$	$0.034X+1.314Y-0.026Z$	$0.106X-0.164Y+0.413Z$
7d	$1.250X+0.286Y-0.197Z$	$0.045X+1.145Y-0.010Z$	$0.049X+0.022Y+0.247Z$
8a	$0.697X-0.025Y+0.249Z$	$-0.048X+0.826Y+0.035Z$	$-0.470X+0.968Y+1.686Z$
8b	$0.766X-0.179Y+0.503Z$	$-0.024X+0.843Y+0.032Z$	$-0.325X+0.384Y+3.315Z$
8c	$1.288X+0.318Y-0.210Z$	$0.074X+1.211Y-0.021Z$	$0.159X-0.178Y+0.391Z$
8d	$1.208X+0.372Y-0.194Z$	$0.044X+1.147Y+0.002Z$	$0.049X+0.072Y+0.220Z$
9a	$0.852X+0.372Y+0.357Z$	$0.080X+0.799Y+0.005Z$	$-0.029X-0.045Y+1.993Z$
9b	$0.831X+0.455Y+0.085Z$	$0.046X+0.870Y-0.082Z$	$0.068X+0.047Y+0.862Z$
9c	$1.216X-0.577Y-0.215Z$	$-0.113X+1.290Y+0.021Z$	$0.014X+0.028Y+0.492Z$
9d	$1.226X-0.623Y-0.156Z$	$-0.070X+1.177Y+0.103Z$	$-0.040X-0.046Y+1.061Z$
10a	$0.689X+0.211Y-0.012Z$	$-0.077X+1.016Y-0.283Z$	$0.019X+0.002Y+2.430Z$
10b	$0.942X+0.005Y+0.054Z$	$0.003X+0.927Y-0.042Z$	$0.027X+0.099Y+1.174Z$
10c	$1.396X-0.279Y-0.018Z$	$0.098X+0.963Y+0.116Z$	$-0.011X+0.004Y+0.403Z$
10d	$1.060X+0.010Y-0.068Z$	$-0.004X+1.075Y+0.034Z$	$-0.032X-0.041Y+0.747Z$

* In terms of the notations used in Tables I, II, and IV, the predictions are of X or X', Y or Y', Z or Z', corresponding to the directions of prediction specified in the legends of Figs. 7–10. The quantities designated X, Y, Z in the formulas in Table IX are either X or X', Y or Y', Z or Z', corresponding to the basis of prediction specified for the corresponding diagram in Figs. 7–10.

Table X. Primaries Deduced from Least-Squares Prediction Formulas.

Figure	x_r	y_r	x_g	y_g	x_b	y_b
7a	0.694	0.264	0.717	−0.031	0.223	0.030
7b	complex		complex		0.163	0.031
7c	0.700	0.270	0.964	−0.142	0.204	0.015
7d	0.762	0.199	2.236	−1.334	0.165	0.001
8a	0.673	0.261	0.601	−0.119	0.215	0.021
8b	0.740	0.196	1.116	−0.317	0.166	0.009
8c	0.675	0.265	1.116	−0.513	0.195	0.003
8d	0.742	0.211	1.680	−0.717	0.170	−0.010
9a	0.701	0.266	2.156	−1.164	0.240	0.019
9b	complex		2.255	−0.677	complex	
9c	0.703	0.263	2.051	−1.051	0.235	0.013
9d	complex		1.571	−0.464	complex	
10a	0.794	0.216	0.441	0.565	−0.040	−0.258
10b	complex		complex		0.226	−0.166
10c	0.793	0.216	0.441	0.563	−0.050	−0.261
10d	complex		complex		0.195	−0.090

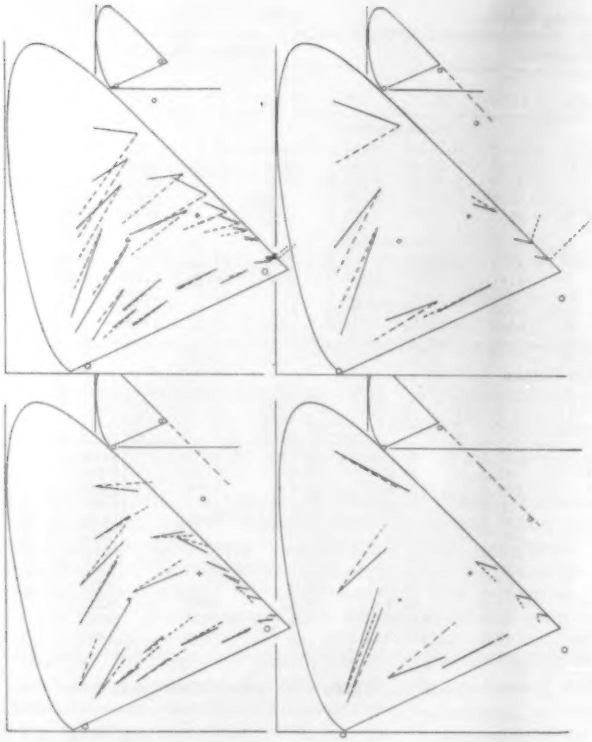

Fig. 8. Comparisons of observed and predicted corresponding colors for adaptations to daylight and tungsten light. For these, the least-squares method was applied to tristimulus values weighted so as to minimize the squares of the deviations of the chromaticity coordinates in a uniform chromaticity-scale diagram.

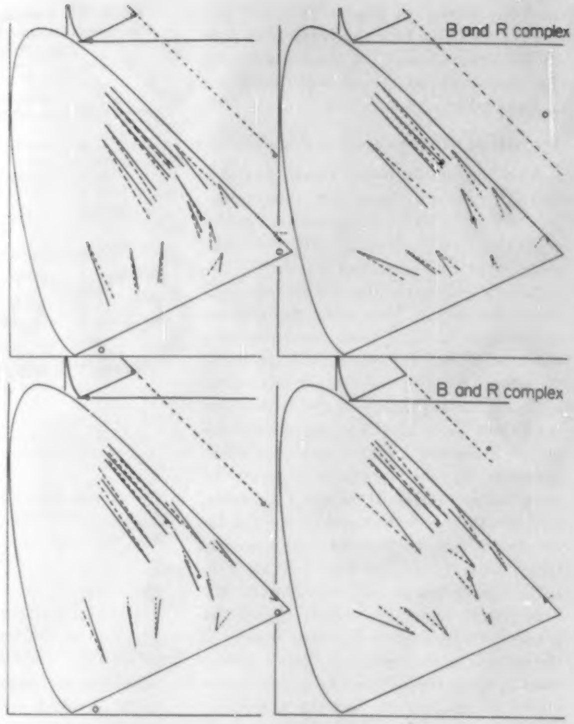

Fig. 9. Comparisons of observed and predicted corresponding colors for adaptations to desaturated green and pink light. Least-squares method applied to data weighted as for Fig. 8.

Hunt's condition will not be imposed. The problem of persistence of metameric matches will be put aside, while an attempt is made to account for corresponding colors observed with different adaptations.

It will be convenient, for the following analysis, to gather together all the terms involving J.

$$\begin{aligned} X &= b_{11}R + b_{12}G + b_{13}V + b_{14}J, \\ Y &= b_{21}R + b_{22}G + b_{23}V + b_{24}J, \\ Z &= b_{31}R + b_{32}G + b_{33}V + b_{34}J. \end{aligned} \quad (2)$$

In Eq. (2), b_{14}, b_{24}, b_{34} are identical linear combinations of the corresponding $b_{11} \ldots b_{33}$

$$\begin{aligned} b_{14} &= c_1 b_{11} + c_2 b_{12} + c_3 b_{13}, \\ b_{24} &= c_1 b_{21} + c_2 b_{22} + c_3 b_{23}, \\ b_{34} &= c_1 b_{31} + c_2 b_{32} + c_3 b_{33}. \end{aligned} \quad (3)$$

Table XI. Adaptation Coefficients.

Figure	Observer	$[R'/R]_{AV}$	$[G'/G]_{AV}$	$[V'/V]_{AV}$
11	DLM	0.73	0.87	2.45
11	EJB	0.74	0.98	3.08
12	DLM	1.00	0.68	1.68
12	EJB	1.01	0.67	1.39
13	DLM	0.31	1.97	14.6
13	EJB	0.26	1.61	11.9
14	DLM	0.81	0.86	2.64
14	EJB	0.87	0.85	1.82
15	DLM	1.46	1.19	0.68
15	EJB	1.24	1.07	0.55
16	DLM	0.79	0.73	6.31
16	EJB	0.80	0.72	9.21

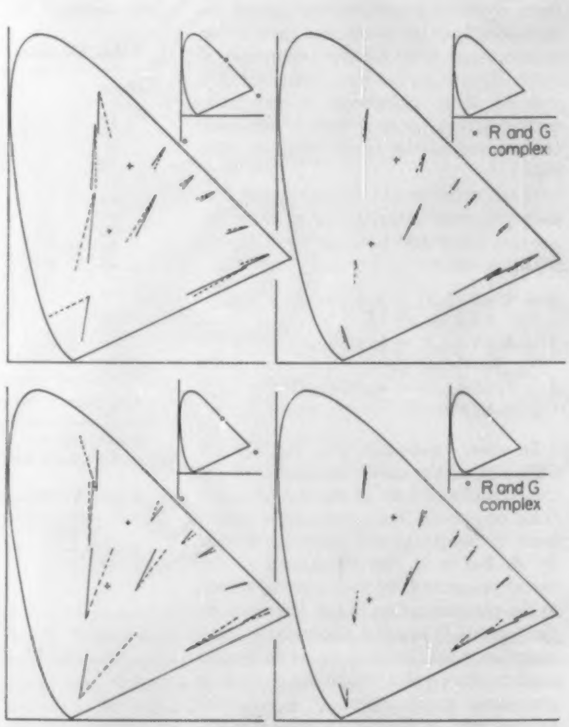

Fig. 10. Comparisons of observed and predicted corresponding colors for adaptations to greenish-yellow and daylight. Least-squares method applied to original experimental data, as for Fig. 7.

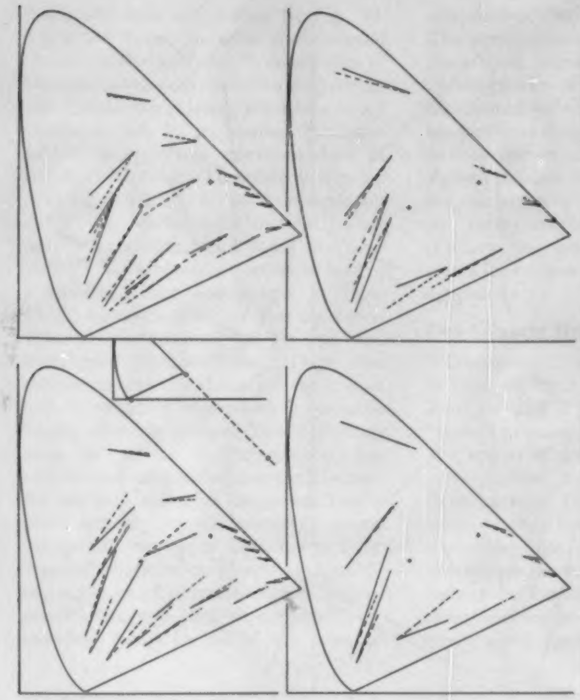

Fig. 11. Comparisons of observed and predicted corresponding colors for adaptations to daylight and tungsten light. Predictions based on Judd P and T primaries and new primary (x = 1.75, y = −0.75), as shown by circles in small-inset diagram. Left, Observer DLM; right, Observer EJB. Top: Predictions of colors perceived with daylight adaptation, corresponding to colors observed with adaptation to tungsten light. Bottom: Predictions of colors perceived with adaptation to tungsten light.

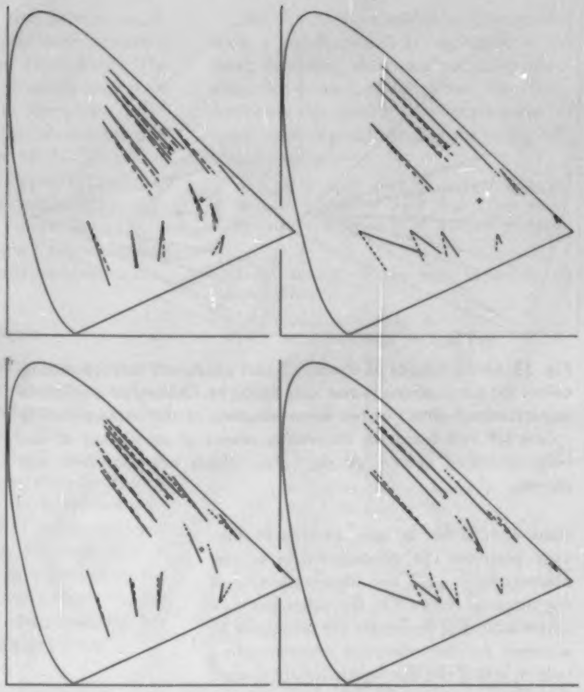

Fig. 12. Comparisons of observed and predicted corresponding colors for adaptations to desaturated green and pink light.

All the b's are independent of adaptation, but R, G, V and J depend upon adaptation according to the extended coefficient law: $R' = k_1R$, $G' = k_2G$, $V' = k_3V$, $J' = k_4J$.

For analysis of deviations from the trireceptor coefficient law, these formulas can be rewritten

$$\begin{aligned} X - b_{14}J &= b_{11}R + b_{12}G + b_{13}V, \\ Y - b_{24}J &= b_{21}R + b_{22}G + b_{23}V, \\ Z - b_{34}J &= b_{31}R + b_{32}G + b_{33}V. \end{aligned} \quad (4)$$

In the manner shown by Brewer's Eq. (8a) (ref. 13, p. 210), the following formulas can be written:

$$\begin{aligned} (X' - b_{14}k_4J) &= m_{11}(X - b_{14}J) + m_{12}(Y - b_{24}J) + m_{13}(Z - b_{34}J), \\ (Y' - b_{24}k_4J) &= m_{21}(X - b_{14}J) + m_{22}(Y - b_{24}J) + m_{23}(Z - b_{34}J), \\ (Z' - b_{34}k_4J) &= m_{31}(X - b_{14}J) + m_{32}(Y - b_{24}J) + m_{33}(Z - b_{34}J), \end{aligned} \quad (5)$$

where the m's are the elements of the matrix $M = BKB^{-1}$, in which B is the matrix composed of the coefficients $b_{11} \ldots b_{33}$, and K is the diagonal matrix consisting of the three adaptation coefficients, k_1, k_2, k_3. It should be noted that the matrix B is the reciprocal of the matrix A used by Brewer.[13]

If the matrix M is applied directly to the CIE tristimulus values X, Y, Z, in an attempt to predict the tristimulus values X', Y', Z', for the prescribed pair of adaptations, errors will result, corresponding to the neglect of the final terms in the following formulas, which are derived from Eq. (5):

$$\begin{aligned} X' &= m_{11}X + m_{12}Y + m_{13}Z - [b_{14}(m_{11} - k_4) + b_{24}m_{12} + b_{34}m_{13}]J, \\ Y' &= m_{21}X + m_{22}Y + m_{23}Z - [b_{14}m_{21} + b_{24}(m_{22} - k_4) + b_{34}m_{23}]J, \\ Z' &= m_{31}X + m_{32}Y + m_{33}Z - [b_{14}m_{31} + b_{24}m_{32} + b_{34}(m_{33} - k_4)]J. \end{aligned} \quad (6)$$

From this it follows that if the tristimulus values

$$\begin{bmatrix} X'_c \\ Y'_c \\ Z'_c \end{bmatrix} = M \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}, \quad (7)$$

predicted without inclusion of the final terms, are subtracted from the tristimulus values X', Y', Z' of the observed colors, and if the hypothesis of four adapting processes is adequate, then the chromaticities corresponding to the discrepancies will be the same for all pairs of corresponding colors, for any particular pair of adaptations:

$$\begin{aligned} x_d &= (X' - X'_c)/(X' - X'_c + Y' - Y'_c + Z' - Z'_c) \\ &= d_1/(d_1 + d_2 + d_3), \\ y_d &= d_2/(d_1 + d_2 + d_3), \end{aligned}$$

where

$$\begin{aligned} d_1 &= b_{14}(m_{11} - k_4) + b_{24}m_{12} + b_{34}m_{13}, \\ d_2 &= b_{14}m_{21} + b_{24}(m_{22} - k_4) + b_{34}m_{23}, \\ d_3 &= b_{14}m_{31} + b_{24}m_{32} + b_{34}(m_{33} - k_4). \end{aligned} \quad (8)$$

Example of calculation of chromaticity of discrepancy of prediction: The tristimulus values predicted for daylight adaptation for the first color specified in Table I are obtained by substituting the original tristimulus values ($X = 21.1$, $Y = 21.8$, $Z = 22.9$) in the equations given in the first line of Table IX. The results are $X'_c = 18.6$, $Y'_c = 17.2$, $Z'_c = 47.1$. When these are subtracted from the observed tristimulus values X', Y', Z' for the corresponding color for daylight adaptation, given in the first line of Table I, the tristimulus values of the discrepancy of prediction are obtained.

$$\begin{aligned} X' - X'_c &= 29.2 - 18.6 = 10.6, \\ Y' - Y'_c &= 16.8 - 17.2 = -0.4, \\ Z' - Z'_c &= 110.9 - 47.1 = 63.8. \end{aligned}$$

The chromaticity of this discrepancy is:

$$\begin{aligned} x_d &= 10.6/(10.6 - 0.4 + 63.8) = 10.6/74.0 = 0.1432; \\ y_d &= -0.4/74.0 = -0.0054. \end{aligned}$$

Experimental errors in the determinations of corresponding colors can be expected to cause some scatter of chromaticities of the discrepancies around the point x_d, y_d. But if the $b_{11} \ldots b_{33}$ are correct, and if there is a fourth adapting process, as hypothesized, then

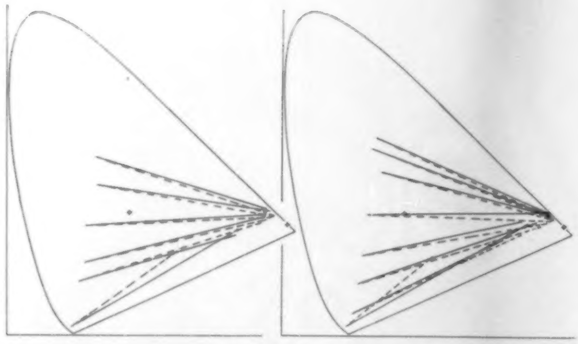

Fig. 13. Comparisons of observed and predicted corresponding colors for adaptations to red and daylight. Otherwise negligible experimental errors in the determination of the corresponding colors for red result in enormous errors of prediction of the corresponding colors for daylight, which are therefore not shown.

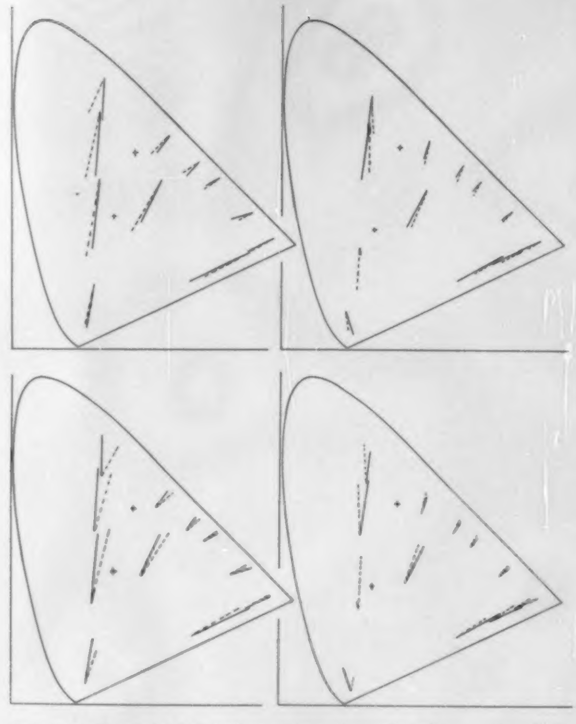

Fig. 14. Comparisons of observed and predicted corresponding colors for adaptations to daylight and desaturated greenish-yellow.

there should not be any systematic relation between the chromaticities of the discrepancies and the chromaticities of the original colors On the other hand, if three adapting processes are adequate to account for the observed corresponding colors, and if the discrepancies are caused only by erroneous evaluation of the matrix M, then the chromaticities of the discrepancies should be projective transformations of the original chromaticities. In an effort to distinguish between these possibilities, chromaticities corresponding to the discrepancies represented in the upper right diagram in Fig. 7 were

Fig. 15. Comparisons of observed and predicted corresponding colors for adaptations to daylight and blue light.

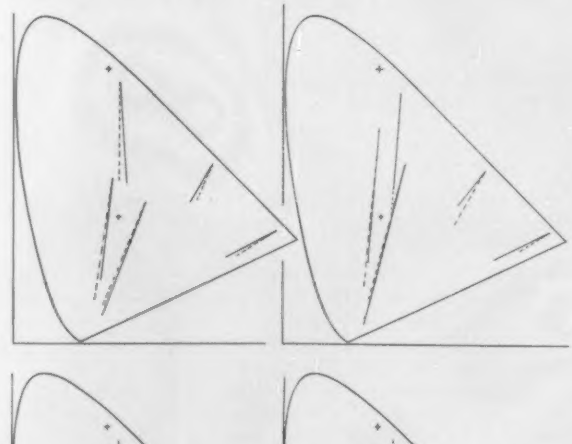

Fig. 16. Comparisons of observed and predicted corresponding colors for adaptations to daylight and green light.

computed and are shown in Fig. 18. Lines are drawn between the observed chromaticities and the chromaticities of the discrepancies. Although some systematic trends are evident, the discrepancy chromaticities, x_d, y_d, cannot be interpreted as projective transformations of the observed colors. Therefore, it appears that the prediction formula obtained by use of the least-squares method is not merely inaccurate, but is based on a false premise: the trireceptor coefficient law.

Similar results are shown in Figs. 19–22, for predictions based on the Judd-Wyszecki primaries, P,D,T, and the trireceptor coefficient law. These discrepancies are too widely scattered to give any information concerning a possible fourth adapting process. Von Schelling, who, in private correspondence, has raised many stimulating questions in connection with this work, suggested that a green primary in the ostensibly green (upper-left) region of the chromaticity diagram might be worth trying. Accordingly, the set of primaries which he proposed[19] has been used to predict corresponding colors for all of the pairs of adaptations used in the present work. The predictions were no more successful than those shown in Figs. 5–16. The chromaticities of the discrepancies were distributed widely over the plane of the chromaticity diagram, in manners similar to those shown in Figs. 18–22. Therefore, a green primary in the upper-left region of the chromaticity diagram is apparently no more successful than Judd's D primary in predicting corresponding colors for various conditions of chromatic adaptation.

Five-Receptor Hypothesis

Discrepancy chromaticities are shown in Figs. 23–26, for predictions based on Judd's P and T primaries and the new "green" primary ($x = 1.75, y = -0.75$). The scatter of the points is much less in each of these diagrams than in any of those in Figs. 18–22. It is remarkable, however, that instead of being clustered around a single point, for each pair of adaptations, as would be expected on the basis of the four-receptor hypothesis, the chromaticities of the discrepancies are spread along nearly straight lines.

The following analysis indicates that such a result would be expected if not four, but five, different adapting processes were contributing to the three responses on which the perception of color must depend. Analogous to Eq. (2), we may write:

$$\begin{aligned} X &= b_{11}R + b_{12}G + b_{13}V + b_{14}J + b_{15}L, \\ Y &= b_{21}R + b_{22}G + b_{23}V + b_{24}J + b_{25}L, \\ Z &= b_{31}R + b_{32}G + b_{33}V + b_{34}J + b_{35}L, \end{aligned} \tag{9}$$

and $L' = k_5L$. From this hypothesis it follows that:

$$\begin{aligned} (X' - b_{14}k_4J - b_{15}k_5L) &= m_{11}(X - b_{14}J - b_{15}L) + m_{12}(Y - b_{24}J - b_{25}L) + m_{13}(Z - b_{34}J - b_{35}L), \\ (Y' - b_{24}k_4J - b_{25}k_5L) &= m_{21}(X - b_{14}J - b_{15}L) + m_{22}(Y - b_{24}J - b_{25}L) + m_{23}(Z - b_{34}J - b_{35}L), \\ (Z' - b_{34}k_4J - b_{35}k_5L) &= m_{31}(X - b_{14}J - b_{15}L) + m_{32}(Y - b_{24}J - b_{25}L) + m_{33}(Z - b_{34}J - b_{35}L), \end{aligned} \tag{10}$$

$$\begin{aligned} X' &= X'_c - (d_1J + e_1L), \\ Y' &= Y'_c - (d_2J + e_2L), \\ Z' &= Z'_c - (d_3J + e_3L), \end{aligned} \tag{11}$$

where d_1, d_2, and d_3 are given by Eq. (8), and

$$\begin{aligned} e_1 &= b_{15}(m_{11} - k_5) + b_{25}m_{12} + b_{35}m_{13}, \\ e_2 &= b_{15}m_{21} + b_{25}(m_{22} - k_5) + b_{35}m_{23}, \\ e_3 &= b_{15}m_{31} + b_{25}m_{32} + b_{35}(m_{33} - k_5). \end{aligned} \tag{12}$$

The chromaticities corresponding to the discrepancies $(X' - X'_c)$, $(Y' - Y'_c)$, $(Z' - Z'_c)$ between colors resulting from five different adapting processes, and predictions based on the assumption of three, would be spread along a straight line between x_d, y_d and x_e, y_e, where

$$\begin{aligned} x_e &= e_1/(e_1 + e_2 + e_3), \\ y_e &= e_2/(e_1 + e_2 + e_3). \end{aligned} \tag{13}$$

The discrepancy chromaticity corresponding to a particular pair of corresponding colors would be the center of

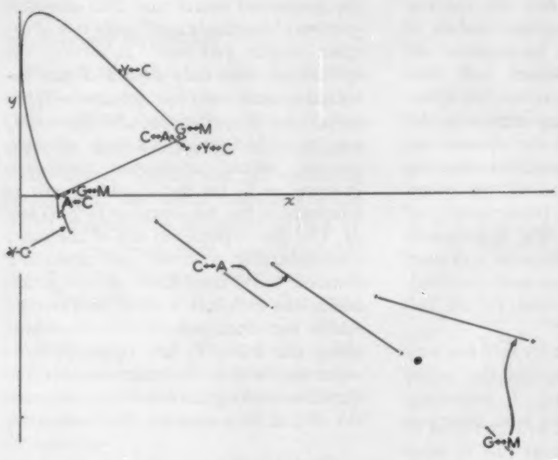

Fig. 17. Locations of primaries indicated by least-squares analysis of data for corresponding colors for indicated pairs of adaptations. Corresponding colors observed with portions of eye adapted to artificial daylight (C) and tungsten light (A) resulted in primaries designated (C←→A). Different blue and "green" primaries are indicated, depending on whether they are derived from formulas for predicting colors observed for tungsten-light adaptation (A) with least-square errors, or from formulas designed for best predictions of colors observed with daylight adaptation (C). Dot near A indicates the primary derived in the first case. Cross near C indicates the primary derived in the second case. For this purpose, the reversed label (A←→C) is used for the blue primaries. The primaries based on the observations by DLM are closest to the label designating the pair of adaptations. The primaries based on observations by EJB are indicated by an arrow from the label. Dots and crosses refer to the same direction of prediction for both observers. No green or red primaries are indicated for EJB for the yellow vs. daylight adaptation (Y←→C), because only complex solutions were obtained from the least-squares procedure. The same was the case for the blue and red primaries for EJB for the green vs. magenta adaptation (G←→M).

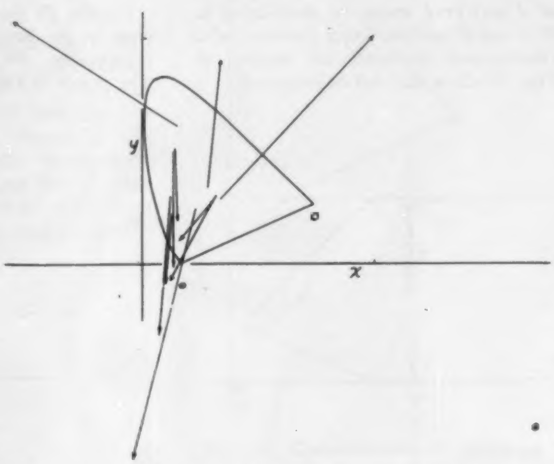

Fig. 18. Arrowheads indicate chromaticities of errors of predictions of colors (tails) by formula based on least-squares method. These are the errors of predictions of colors perceived by EJB with daylight adaptation, corresponding to colors observed with daylight adaptation (upper right diagram in Fig. 7). Primaries corresponding to least-squares prediction formula are indicated by circles.

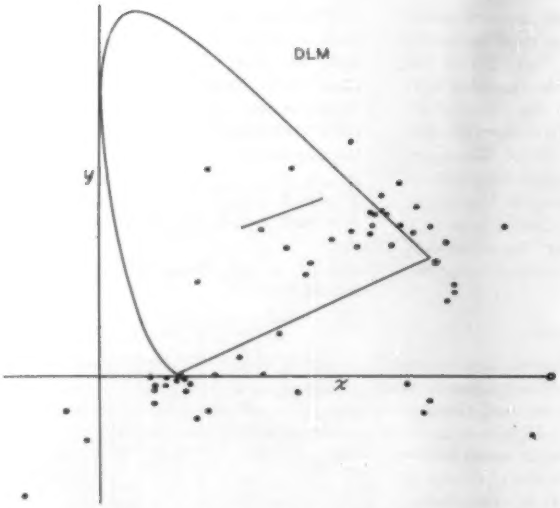

Fig. 19. Chromaticities of errors of predictions in the lefthand diagrams in Fig. 5, based on Judd's primaries (shown by open circles). Adapting colors (daylight and tungsten light) are represented by ends of line segment.

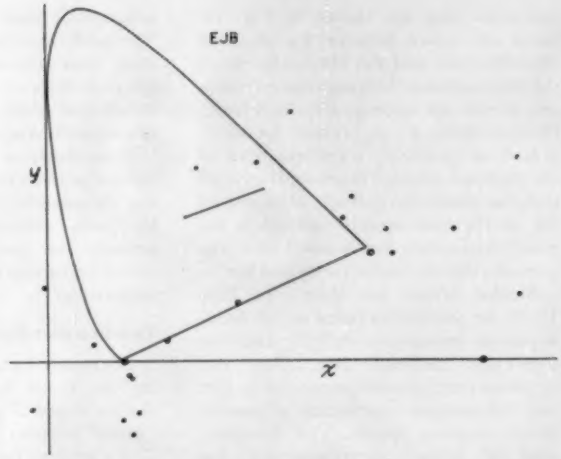

Fig. 20. Chromaticities of errors of predictions in the righthand diagrams in Fig. 5.

gravity of weights J and L placed at the points (x_d, y_d) and (x_s, y_s). The values of those weights would be given by the integrals

$$J = \int P_\lambda J_\lambda d\lambda, \quad L = \int P_\lambda L_\lambda d\lambda, \tag{14}$$

where P_λ is the spectral distribution of the original color and J_λ and L_λ are spectral sensitivities of the fourth and fifth adapting processes.

Those spectral sensitivities must be different from the spectral sensitivities of the R, G and V receptors, and are *not representable as linear combinations* of those sensitivities. Otherwise, the contributions of J and/or L could be assimilated in R, G and V, and the linear distribution of discrepancy chromaticities shown in Figs. 23–26 would not be obtained.

The present investigation is not adequate to determine either the spectral sensitivities or the integrated values of J or L. It serves only to indicate the existence of such processes and their rôles in chromatic adaptation. The linear arrays of the discrepancy chromaticities in Figs. 23–26 provide the clearest indications of the presence of five adapting processes. The locations of the points (x_d, y_d) and (x_s, y_s) and consequently, of the lines along which the discrepancy chromaticities are distributed, depend upon the pair of adaptations involved, and seem to differ somewhat for the two observers.

On Fig. 23, the points for EJB are very close to the line connecting the points representing the P and T primaries. The points in Fig. 24 for both observers when adapted to green and magenta are very close to the line connecting the points representing the T primary and the new green primary. Such relationships between the discrepancy chromaticities and the primaries would result if the postulated fourth and fifth adapting processes "contaminated" only two of the three major processes. However, the indications that only P and T are involved in some cases (notably $A \longleftrightarrow C$) but only T and D in others (notably $G \longleftrightarrow M$) may be an indication of a sixth adapting process, whose adaptation coefficient is equal to k_2 for the A and C pair of adaptations but not equal to k_2 for G and M. On this hypothesis, one of the other contaminating processes (affecting the P response only) must have its adaptation coefficient different from k_1 in cases for which the discrepancies are distributed along the line PT, but equal to k_1 in cases for which the discrepancies are distributed along the line drawn between the T and D primaries. The remaining

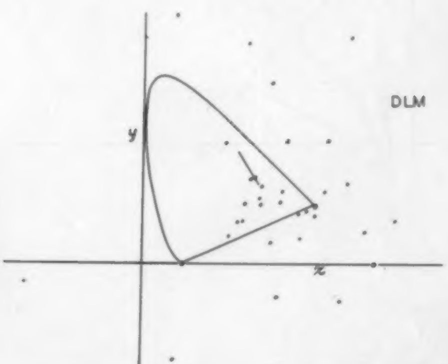

Fig. 21. Chromaticities of errors of predictions in the lefthand diagrams in Fig. 6.

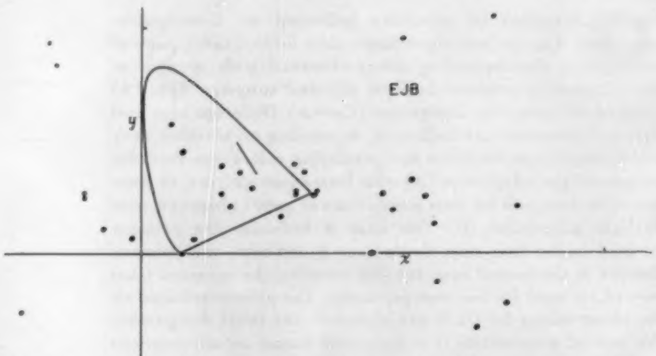

Fig. 22. Chromaticities of errors of predictions in the righthand diagrams in Fig. 6.

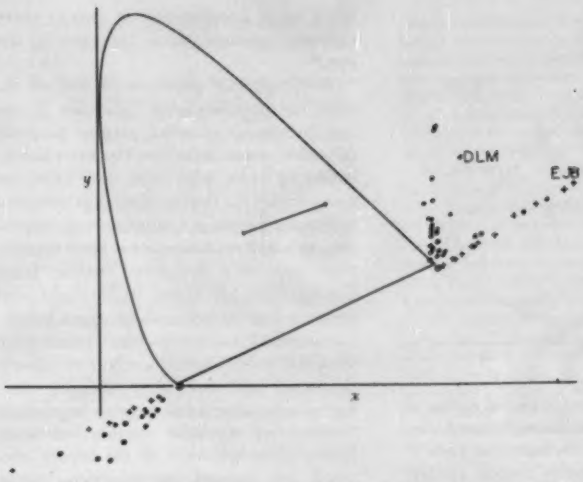

Fig. 23. Chromaticities of errors of predictions in Fig. 11, based on Judd P and T primaries (shown by open circles) and new "green" primary (x = 1.75, y = −0.75). Adapting colors are represented by ends of line segment. Dots represent errors of predictions for DLM (lefthand diagrams of Fig. 11). Crosses represent errors of predictions for EJB (righthand diagrams of Fig. 11).

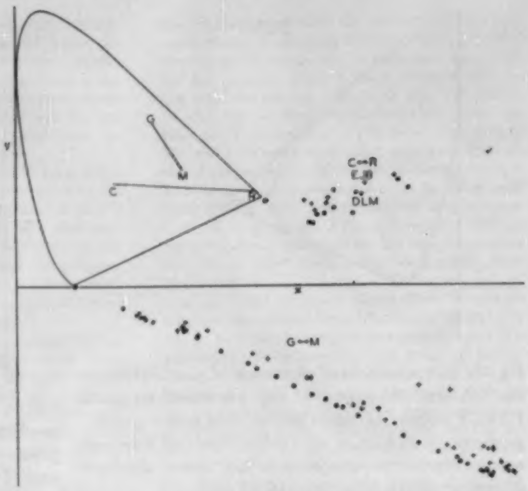

Fig. 24. Chromaticities of errors of predictions in Figs. 12 and 13, based on Judd P and T primaries (open circles) and new "green" primary (x = 1.75, y = −0.75). Ends of line segment RC represent red and daylight adapting colors, for which errors of predictions of corresponding colors are indicated (above the x-axis) by dots for Observer DLM and by crosses for Observer EJB. Ends of line segment GM represent green and magenta adapting colors, for which errors of predictions are indicated (with same code) below the x-axis.

cases in Figs. 23–26 cannot be explained so easily.

Six-Receptor Hypothesis

Figures 27 and 28 indicate the discrepancy chromaticities for the greenish-yellow and the daylight pair of adaptations. In these figures, the discrepancies seem to vary widely and are randomly distributed for both observers. The errors of prediction indicated in Figs. 10 and 14 are larger than can reasonably be attributed to experimental error. It therefore appears that a sixth adapting process is present, but that it is differentiated from all of the other five adapting processes. This is the case for this pair of adaptations alone of all of the pairs of adaptations used in this investigation.

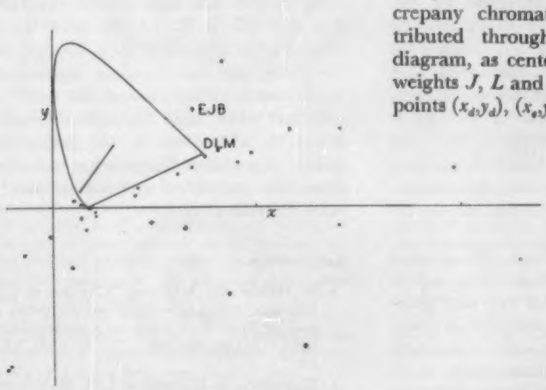

Fig. 25. Chromaticities of errors of predictions in Fig. 15 based on Judd P and T primaries (open circles) and new "green" primary (x = 1.75, y = −0.75). Ends of line segment represent blue and daylight adapting colors. Errors of predictions are indicated by dots for DLM and by crosses for EJB.

The hypothesis of six different adapting processes, stimulating the three responses necessary and sufficient to account for color-mixture data, is expressed by

$$
\begin{aligned}
X &= b_{11}R + b_{12}G + b_{13}V + b_{14}J + \\
&\qquad b_{15}L + b_{16}N, \\
Y &= b_{21}R + b_{22}G + b_{23}V + b_{24}J + \\
&\qquad b_{25}L + b_{26}N, \\
Z &= b_{31}R + b_{32}G + b_{33}V + b_{34}J + \\
&\qquad b_{35}L + b_{36}N,
\end{aligned}
\tag{15}
$$

and $N' = k_6 N$.

From these, in a manner similar to that used in the analysis of the hypotheses of four and five different adapting processes, it can be deduced that the discrepany chromaticities should be distributed throughout the chromaticity diagram, as centers of gravities of three weights J, L and N, located at the three points (x_d, y_d), (x_e, y_e), and (x_f, y_f) where

$$
\begin{aligned}
f_1 &= b_{16}(m_{11} - k_6) + b_{26}m_{12} + b_{36}m_{13}, \\
f_2 &= b_{16}m_{21} + b_{26}(m_{22} - k_6) + b_{36}m_{23}, \\
f_3 &= b_{16}m_{31} + b_{26}m_{32} + b_{36}(m_{33} - k_6).
\end{aligned}
\tag{16}
$$

The locations of those three points

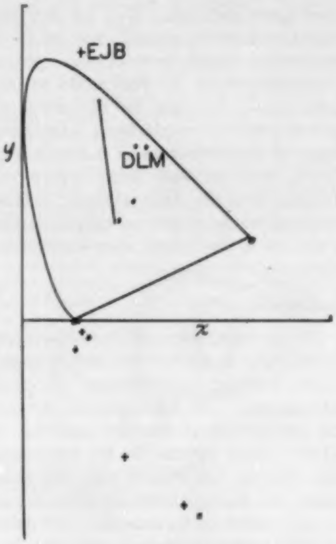

Fig. 26. Chromaticities of errors of predictions in Fig. 16, based on Judd P and T primaries (open circles) and new "green" primary (x = 1.75, y = −0.75). Ends of line segment represent green and daylight adapting colors. Errors of predictions are indicated by dots for DLM and by crosses for EJB.

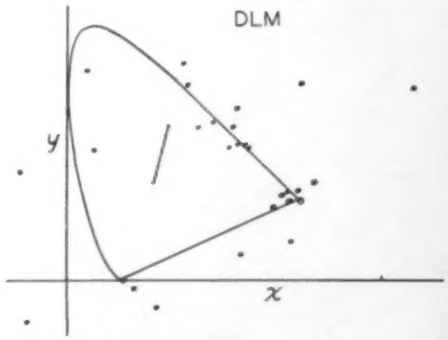

Fig. 27. Chromaticities of errors of predictions in the lefthand diagrams of Fig. 14, based on Judd P and T primaries (open circles) and new "green" primary ($x = 1.75$, $y = -0.75$). Ends of line segment represent greenish-yellow and daylight adapting colors. Observer DLM only.

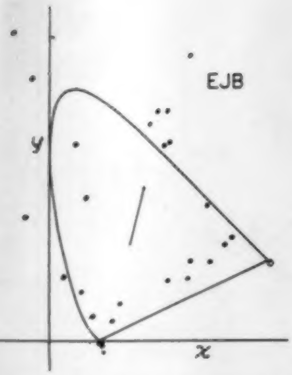

Fig. 28. Chromaticities of errors of predictions in the righthand diagrams of Fig. 14, based on Judd P and T primaries (open circles) and new "green" primary ($x = 0.75$, $y = -0.75$). Ends of line segment represent greenish-yellow and daylight adapting colors. Observer EJB only.

vary according to the pair of adaptations. The distribution of discrepancies should not correspond to a projective transformation of the observed colors, because J, L and N are not linear combinations of R, G and V. Therefore, the effects of six different adapting processes should be distinguishable from the effects of merely erroneous evaluation of the prediction matrix, discussed previously. If the sixth process, N, contaminates only one of the principal processes, R, G or V, the effects of adaptation should be representable as consequences of five different adaptation processes (with linear distribution of discrepancies from predictions of the trireceptor coefficient law) for any pair of adaptations for which k_6 is equal to the adaptation coefficient of the process contaminated by N. This seems to have been nearly the case for all except the greenish-yellow vs. daylight adaptation. Some of the deviations of points in Figs. 23–26 from straight lines may be attributable to the sixth adapting process, although in the present investigation there is no way to distinguish such small effects from experimental errors.

Conclusions

The trireceptor coefficient law seems inadequate to account for corresponding colors observed with different chromatic adaptations. The discrepancies between the predictions of that law and the observed colors appear to be systematic. An analysis has shown that, for many cases, the discrepancies are such as may be accounted for by assuming five differently adapting processes in the eye, which together stimulate the three responses that are necessary and sufficient to account for color perception. In one case studied, there seemed to be evidence of a sixth different adapting process. The degeneracy of a six-process system to the equivalent of a five-process system is readily understandable.

The present investigation raises far more questions than it answers. There is no way, by use of the present data, to deduce the spectral sensitivity of any of the five or six different receptor processes which seem to be necessary to account for the dependence of corresponding colors on chromatic adaptation. Perhaps the present results will stimulate other workers to devise more powerful methods for studying in detail the effects of chromatic adaptation and of the visual processes which produce them.

Wyszecki has recently shown that if metameric matches are not disturbed by changes of chromatic adaptation, then the trireceptor coefficient law is necessarily exact and general.[20] Therefore, if, as suggested by the present results, the trireceptor coefficient law does *not* adequately predict corresponding colors for different chromatic adaptations, then some metameric matches must be disturbed by changes of chromatic adaptation. No cases of such disturbance for moderate adaptation intensities are known. It is conceivable that more careful study of the effects of chromatic adaptation on metameric colors will prove as powerful a method as determinations of corresponding colors, for verification of the hypothesis of five or six receptor processes.

It may be noted that the present results and the hypotheses proposed to account for them do not call into question the trichromatic character of color perception, on which color measurements, color photography and color television are all based. Apparently, the visual nervous system provides only three channels to the perceptual centers, capable of handling only three independent responses for color perception. But each of those responses appears to be stimulated by a combination of two or more different photosensitive processes in the eye.[21]

Although the presence of five or six different photosensitive processes in the eye does not jeopardize present methods of color measurements, color photography or color television, their behavior complicates the design of systems intended to translate from one condition of adaptation to another. Attempts at such translation are very frequent: many color photographs are taken in daylight and projected or viewed with tungsten lamps: commercial motion pictures made with tungsten studio lamps are almost always projected with arcs that resemble daylight; color-television receivers produce "white" of daylight quality, or even bluer, although most of the scenes televised are lighted by tungsten lamps. For the optimum design and adjustment of materials and devices intended for such use, an accurate knowledge of the dependence of corresponding colors on chromatic adaptation is a necessity.

The trireceptor coefficient law, on which all such design has tacitly been based in the past, now appears to be only a crude first approximation. Further work is required, perhaps with results generalized on the basis of five or six different adapting processes, so that methods of designing such materials and devices can deal adequately with the effects of chromatic adaptation on color perception. More immediately, however, all who deal with color can be aware of the effects — their character and magnitudes. On the basis of such knowledge, sequences of scenes can be planned to avoid objectionable adaptation effects. Some adaptation effects are spectacular and even beautiful and might be deliberately induced by some who are fully aware of the possibilities and the conditions of their control. Screen surroundings and ambient lighting in theaters have important effects on chromatic adaptation[22] and should be designed and controlled so as to avoid undesirable effects. Color-television transmitters need automatic gain controls on the three camera channels, equivalent to chromatic adaptation of the eye.[23] A standard white that corresponds realistically to adaptation to the prevailing quality of ambient illumination in homes should be established and maintained in color-television receivers.

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Discussion

W. W. Lozier (National Carbon Co.): How is adaptation affected by the intensity of the adapting light? In particular I am wondering how the situation is affected by a theater that has a low level of house lights or say an outdoor theater that has practically dark surrounding; how does the intensity of the adapting light affect that change of color appearance?

Dr. MacAdam: If the prevailing luminance is less than, about, 10% of the luminance of the screen with the picture on it, then the adaptation is not very dependent upon the surround. However, in the case of appreciable border lighting, or in the home where somebody is trying to read the newspaper in another corner of the room, the adaptation luminance is likely to attain higher and significant values.

G. L. Beers (Radio Corp. of America): In the examples in the slides, where you showed the differences in ambient light in the store, the area which was illuminated with that ambient illumination was essentially white. In the home, assuming that one housewife might employ, a color scheme using an orange wall and another a decidedly blue wall, illuminated either with tungsten or with fluorescent lighting, would not the impressions then created with the same color receiver be radically different?

Dr. MacAdam: Yes, there would be some effect but I think it's rather small as compared to the large difference of quality we're speaking about: the difference between tungsten light and daylight. However, the color which probably has the greatest influence on adaptation in the ordinary home is the color of the lighting fixture itself. That is usually much brighter than any of the indirectly lighted walls or furniture.

Dr. Beers: In a number of color demonstrations which we gave, we used back-lighting on walls back of the receivers, so that we did not create the impression of looking at a headlight or a very bright image. We found that the color of the lighting on the wall back of the instrument was very critical in terms of determining the impression of colors in the picture itself.

Dr. MacAdam: I'm sure that would be true if the light source itself were not in the field of view. Incidentally it is interesting to note what happens if the ambient light is so low that one needn't be concerned with it.

Mr. Sproson published in the *BBC Quarterly* [vol. 8, pp. 176–192, 1953] the results of his study of that. He had a mock-up of a receiver in a completely darkened room and he exhibited various color temperatures on the screen, in random sequence, and asked twelve normal observers to name the colors. The average for "white" was 4200 degrees color temperature. So, even when there is no ambient, white seems to correspond to something lower than the color temperature of daylight. For tungsten quality ambient, which Sproson reports is used by 88% of the British audience, he recommends a white at 3500 degrees.

Donald G. Fink (Philco Corp.): I think we can all agree with the technical desirability of requiring the minimum of adaptation in viewing color television. But I think an even tougher technical task, on which I hope you can give the color television industry some guidance, is the question of adapting an art during the transition stages. I think we can agree that even with the big push in color television that's coming up this fall, well over 90% of the programs are going to be in black-and-white and the color receiver must produce a picture, when it is reproducing a black-and-white program, which has the same general impression of excellence as the black-and-white receiver which the owner has traded in in order to get his color set.

Now the fact is, for reasons which seem to be very obscure among the technical part of the industry, but very clear to the salesmen, that the public wants an extremely "blue" white in a black-and-white television set. The screens all tend to be bluer than illuminant "C," say, 8000 K or something of that order, and the industry has set up a standard which permits this, and in fact encourages it.

Now unless you go to considerable trouble in a color set to correct that condition when you go over from monochrome reception to color reception, you're stuck with it, because you're trying to do the job that the public is used to for monochrome reception. This is a very big stumbling block for color television. I'm sure that it is tied up with the question of adaptation, and my question is, is there any guidance or consolation or whatever that we can get from those nice big arrows on your CIE diagrams, which would indicate what the broadcasters should do, being stuck with illuminant "C" or bluer as a reproducing illuminant, in the illumination they use in the studio, the color of the sets and the costumes?

Dr. MacAdam: Speaking of the folks who handle the studio equipment, I understand they don't want to do anything, they want white objects in the studio to produce automatically a zero chrominance subcarrier. They want to let the receiver deal with the rest of the problem. As a matter of fact, the FCC specifications said just as much about the transmitted signal. As for the receiver, I don't know whether one can dig into the ancient history of why the public, or why the salesmen think the public wants the blue set. I suspect that it's because most sets, in the early days at least, were purchased during the daytime when there was diffused daylight kicking around the salesroom or perhaps with some diffused light from fluorescent lamp fixtures. I've said in print that I don't know why this has occurred, but I think it's for the best long-range interests of color television that we get away from bluish whites.

C. J. Staud (Eastman Kodak Co.): I wonder whether this desire for a blue-black image may not go back to black-and-white photography of a very early day because the color images in monochrome prints have been on the cold side for many years and those of us concerned with research development and manufacturing photographic paper have been bedeviled by this on the one hand, while on the other hand we are further bedeviled by it because there's some of us who think that warm-tone images on amateur black-and-white prints are preferable and feel that we can see greater detail in such prints. But the photofinisher has decided he wants black-and-whites which are blue-black and the customer has apparently been conditioned to it—I'm not sure of the mechanism there. Also in the case of black-and-white motion pictures, the color of images there if on the warm side, has not been acceptable, in general, and those of us who fought the battle of 1302 were up against that problem for a long time. So this is not a new problem, the genesis is not very clear, but I thought that possibly the comment on the earlier type of blue-tone image might be relevant to the discussion.

Dr. Lozier: I just wanted to add one bit on this discussion of the warmer color and the cooler color in motion-picture projection as the last commenter stated. I know we have had the experience where we have projected with the so-called low-intensity compared with the high-intensity arc which gives a bluer light and have adjusted and measured very carefully to obtain the same foot-candles on the screen; but if we have exactly the same foot-candles on the screen, the bluer light looks the brighter. That may hold true with a home television set and may be one reason why people like it better, because it does look brighter, even though the foot-candles on the screen are the same.

Dr. MacAdam: I agree that blue light does look brighter than white light at the same foot-candle value. But, I don't think that that increase is enough to compensate for the other disadvantages of the "cold" appearance of the picture.

Dr. Beers: There's another factor which comes in in the case of television and that is, with television reproducing tubes, if you have them on the blue side you actually get more light. That's particularly true in the case of a tricolor tube. The red phosphor in a tricolor tube is the one which, at the moment, is relatively weak. With regard to your experience of setting up pictures for a color temperature something of the order of 4500, we have at times had men set up receivers just to determine what color values they would prefer—without reference to a particular color temperature—and found that invariably they seemed to set them up for color temperatures above 6000. This seems to differ a little from your experience of 4500.

Dr. MacAdam: The result I cited (4200 K) was obtained by W. N. Sproson of the Research Department of the British Broadcasting Corporation. He tried the method you outlined, but concluded that it is unwise to give the observer control over the variables. He developed and recommends a procedure of naming samples exhibited in random order. Even for adaptation to north sky light (blue), Sproson found the average color temperature for the "white" response to be 4460 K, and concluded that "the whites reported in the American color television literature are definitely too blue."

High Efficiency Rear-Projection Screens

By C. R. DAILY

Using a new type of high efficiency rear-projection screen, a 40-ft wide projected color picture can now be photographed on standard Eastman Color Negative Film, Type 5248, with the camera operating at $f/4$ at 24 frames/sec. Data are presented on the transmission and reflectance characteristics of this new screen, together with data on several other experimental screens which have wide-angle and high-transmission characteristics.

THE INTRODUCTION of wide screens in theaters required that all steps in the photographic process be improved. In order to improve the definition of the original production negative, Paramount Pictures Corp. developed and started using the horizontal double-frame VistaVision cameras in December 1953. By the fall of 1954 the improved standard-size theater prints, made by reduction from the double-frame negative, were in use. A still further improvement in exhibition was achieved in the spring of 1955 when the first horizontal double-frame theater projection prints were released. As a part of this improvement program, optical printers used in special effects work were converted to double-frame operation immediately following the start of VistaVision productions.

The need for an improvement in transparency projection was also evident and the conversion of the triple-head background projectors from single-frame to double-frame projection was also started in the fall of 1954. The improved quality of the horizontal double-frame contact prints, made from double-frame original negatives, was needed so that the rephotographed transparency backgrounds would match in quality with the improved photography of the foreground action. The use of a double-frame print in the transparency projector rephotographs with less grain and higher definition than the projection of a single-frame print. In the process of converting the triple-head projectors from single to double-frame, it was also possible to obtain much more total light output. Higher definition projection lenses were also made up.

The newly designed horizontal movement double-frame transparency projectors have worked out very well in production service. Two complete triple-head units have been completed and have been in service for many months.*

Presented on May 2, 1956, at the Society's Convention at New York by C. R. Daily, Paramount Pictures Corp., 5451 Marathon St., Hollywood 38.
(This paper was received on June 11, 1956.)

Triple-Head Background Projection System

Figure 1 shows in diagrammatic form the horizontal double-frame projection system for a single projector. Figure 2 shows the method of using three projectors simultaneously with identical images superimposed on the transparency screen. Figure 3 shows the dimensions of the horizontal double-frame image areas. VistaVision cameras and transparency projectors have apertures measuring 1.485 × 0.991 in. Double-frame release prints are contact printed from this negative using 1.418 × 0.7225 in. Standard release prints are made with a 1.62 linear reduction factor from an area 1.3365 × 0.805 in. on the double-frame negative.

* This improved triple-head design received an award in March 1956 for technical excellence from the Academy of Motion Picture Arts and Sciences and will be described in detail and demonstrated at the Society's Convention to be held at Los Angeles in October 1956.

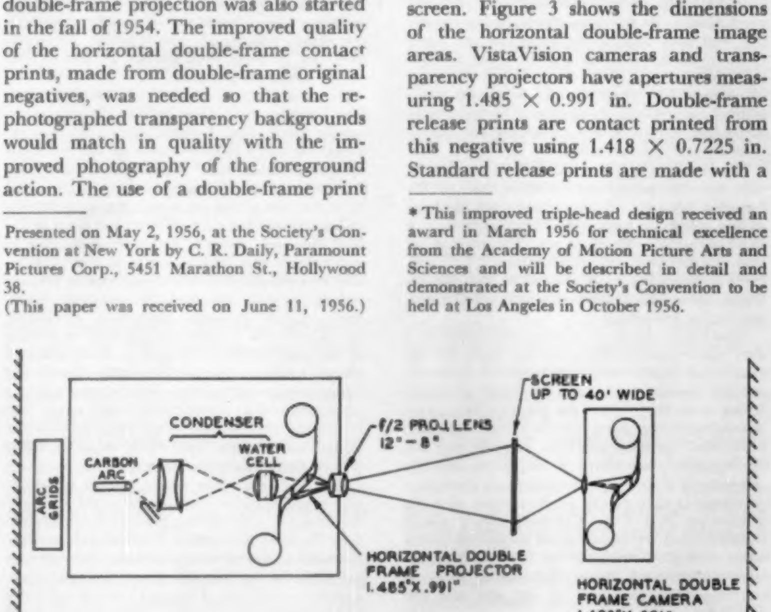

Fig. 1. VistaVision horizontal double-frame background projection system schematic.

Improved Transparency Screen

Paralleling the development of the new transparency projectors, the whole problem of higher efficiency translucent screens was again taken under study since the wide screen called for shots of greater width. *The first phase of this screen program has now been completed with the development of the new Hi-Trans screen which will now permit us to make transparencies up to 40 ft in width in color with the camera lens operating at $f/4$.* The new screen has much less internal diffusion than formerly used. This change raises the transmission of the screen and likewise makes it appear darker on the stage in the presence of fill lights. A rougher texture to the surface also improves the distribution of light. With the earlier standard screens, the new double-frame projectors had only enough light for a maximum picture width of 28 ft. By comparison, the previous single-frame transparency projectors provided only enough light for a 16-ft width picture, again using standard screens.

A great deal of work had been done in the past by many people on this project but no significant improvement had been made in the design or performance of transparency screens for many years. It is the purpose of this paper to outline the results of this new screen study and suggest additional steps which may be taken by the Industry in the future to gain even greater improvements.

This study was aimed at obtaining a higher efficiency screen over a wider pickup angle and it took into account the many factors of screen design and manufacture. Three basic types of screens were considered: (1) the Fresnel type, which was known to have the highest efficiency potential; (2) lenticular screens of the symmetrical and asymmetrical types; and (3) symmetrical diffusion type screens of improved characteristics.

Method for Checking Screen Materials

Figure 4 shows a conventional setup for the determination of screen properties as a function of the various angle factors involved in transparency projection. Variations of the projector angle α simulate the requirements of transparency projection where projector lenses of various focal lengths are used. Variations of the angle Θ correspond to variations encountered with camera lenses of various focal lengths. It is also used in

the determination of the reflection characteristics of screens since this is an important factor because of the need of fill light which reflects from the front of the screens.

A standard magnesium carbonate block is substituted for the screen samples to provide a standard brightness reference. The brightness of this material has been assigned an arbitrary value of 1.0 and all other brightness measurements are referred to this value.

The Spectra Spot Brightness Meter was used for close-up measurements of the finer grained screen samples. A camera was also used as a brightness meter for the checking of various types of lenticular and Fresnel samples.

Angles Encountered in Transparency Projection

A simplified schematic of the projector and camera angles is shown in Fig. 5, referred to the corner of the picture. The total bend angle $\alpha + \beta$ will be the highest angle encountered if the camera and projector are on the same axis. For off-axis work, the maximum bend angle may considerably exceed this value.

Table I shows the total bend angle $\alpha + \beta$ at the corner, side and top of the double-frame camera and projector aperture for double-frame projection lenses varying from 12 in. down to 6 in. and for double-frame camera lenses varying from 100 mm down to 40 mm. These data assume that the camera and projector are on the same axis and that the full aperture of the projector is imaged to the same size aperture in the camera. The data of Table I are graphically presented in Fig. 6 for the case of the total bend angle at the corner of the camera and projector aperatures.

The maximum bend angle that can be used in any given case will vary with many factors including:

1. Type of screen material.
2. Illumination level required and available from projectors.
3. Size of projected picture required.
4. Depth of field required for foreground subjects.
5. Total distance available on stage between back of projector and back of camera.
6. Nature of scene being projected and rephotographed.
7. Amount of off-axis required of camera and/or projectors.

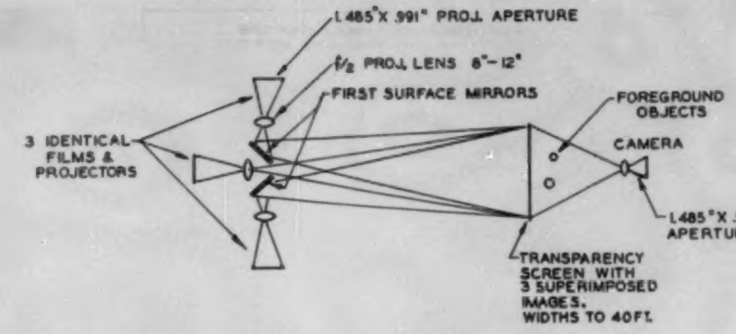

Fig. 2. Triple-head transparency projection schematic.

Fresnel Screens

About 1936 Paramount made a study of the Fresnel-type transparency screen to determine its advantages and limitations. Small screens were made up at that time and a high increase in efficiency was immediately apparent. Imperfections in manufacture and difficulty of construction on a large scale made it impractical to put this type of screen into use. Since that time many organizations have worked on this problem with a variety of commercial applications in mind.

The study reported in this paper started with some of the plastic Fresnel screens available on the market, including the Ektolite field lens which is supplied for use in camera viewers. Since a transparency screen should have a thickness less than 0.020 in., the depth of the grooves of the Fresnel lens structure should be less than 0.005 in. in order to retain sufficient structural strength in the screen. The small Ektolite field lenses were therefore well suited for this experimental problem since they

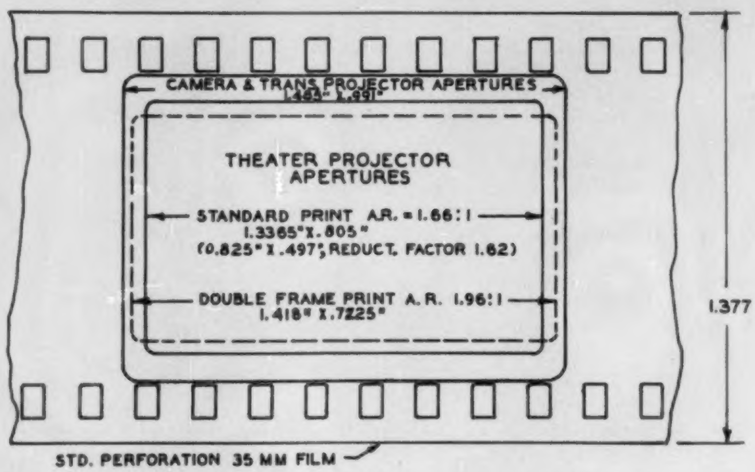

Fig. 3. VistaVision horizontal camera and projector aperture dimensions.

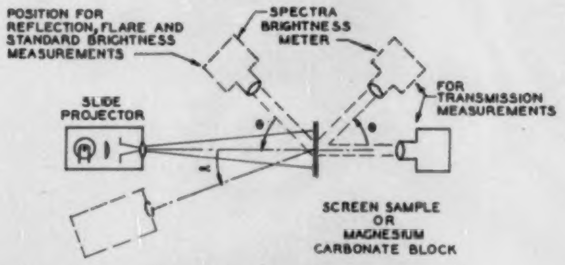

Fig. 4. Screen brightness measurement setup.

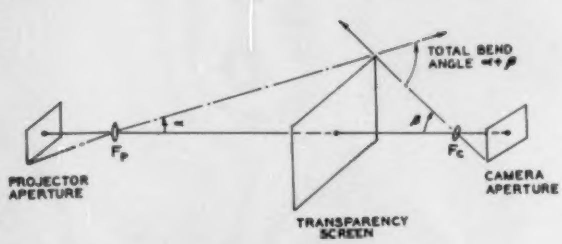

Fig. 5. Bend angles for transparency photography.

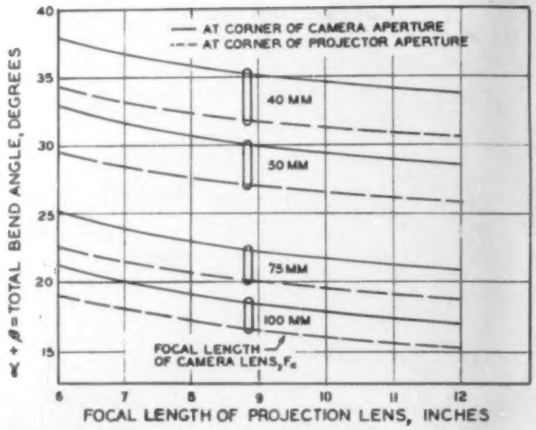

Fig. 6. Bend angles vs. focal length of projection lens for various camera lenses.

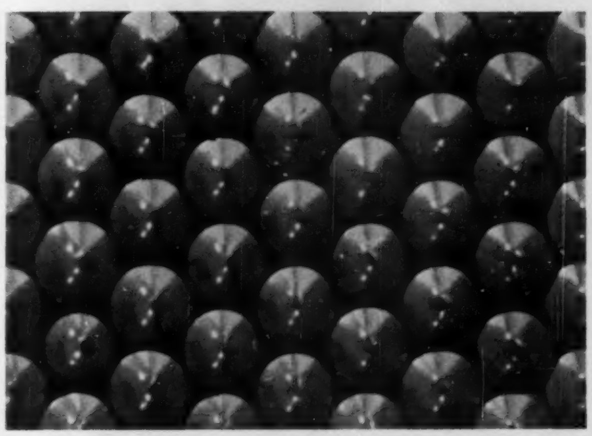

Fig. 7. Schwesinger Lenticular Screen: Front view of lenticules with flattened and painted areas between lens elements.

have 200 grooves to the inch with a maximum depth of groove of 0.005 in.

The Ektolite lenses are of a rigid cast plastic type. Using one of these lenses as a positive master, the first step was to flow and spray coat this lens with clear plastic material, making a flexible negative mother lens. This negative duplicate was then stripped from the original Ektolite, turned over and spray coated again with clear plastic, recreating the original positive lens but in a thin flexible form. This duplication work was carried out with the fine cooperation of the Stewart-Trans Lux Corp. It was found that the duplicate positive lens had retained its lens characteristics and that the focal length was only slightly longer than the original, this being attributed to a slight flattening of the groove angles during the duplication process. Some fine bubbles were occluded in the duplicate lens and these aided to some degree in slightly diffusing the beam.

It was further determined that it was advantageous to combine the Fresnel lens with a high-transmission, symmetrical, diffusion-type of screen in order to even out the illuminated field while still retaining an efficiency about six times greater than that obtained with standard diffusion screens. The diffusion screen was placed nearest to the projector and the grooves of the Fresnel screen were held in contact with the diffusion screen by sealing the edges of the two screens together and applying a low vacuum to the space between them. The smooth outer surface of the Fresnel portion would face the camera and therefore would be given a suitable rough spray coat to minimize flare from the fill lights near the camera.

When using more than one projector with superimposed pictures, it is well known that the image on the screen must be located in only one plane. With this double-screen construction the original image is formed in the normal manner on the regular diffusing screen, which meets the above requirement. The lens screen then redirects the light to the camera. This combination was found to have considerable axial latitude for the camera and a small but usable lateral mobility. The total bend angle at the corner exceeded 30° and this might be still further increased with more accurate duplicating techniques and the use of higher index duplication screen materials.

A possible way of constructing a very large master Fresnel might be to edge wind narrow thin ribbon on a flat turntable. This ribbon might be metal or possibly even ¼-in. wide stiff plastic film such as motion-picture film base. This ribbon would be run through a small milling machine which would first cut or plane a true flat bottom side to one edge of the ribbon and then, in a subsequent operation, bevel the top edge at the desired height and angle required for a particular portion of the Fresnel screen. This method would permit cutting of all of the Fresnel elements in strip form before assembly. The strips would then be spliced end to end and wound on the turntable. This master structure would be cumbersome and heavy. The negative duplicate material would then be applied. As described above, this negative would then be stripped off and be available for use in making duplicate positives at a later date. When the negative was not being used for making duplicate positives it would be carefully rolled up and stored. This would eliminate the need for keeping and storing the original large, rigid, heavy master positive. More work is needed to perfect all steps in this procedure.

Table I. Bend Angles for VistaVision Camera and Projector Apertures at Corner, Side and Top of Frame vs. Focal Lengths of Camera and Projector Lenses.

Proj. lens F_p		Camera lens, F_c							
		100mm		75mm		50mm		40mm	
		C.A.	P.A.	C.A.	P.A.	C.A.	P.A.	C.A.	P.A.
12-in.	Corner	17°01′	15°14′	20°56′	18°46′	28°36′	25°49′	33°46′	30°39′
	Side	14°12′	13°36′	18°27′	16°47′	24°11′	23°11′	28°44′	27°34′
	Top	9°33′	6°59′	11°47′	8°38′	16°27′	12°06′	19°47′	14°39′
10-in.	Corner	17°53′	15°59′	21°48′	19°31′	29°28′	26°34′	34°38′	31°24′
	Side	14°56′	14°16′	19°11′	17°27′	24°55′	23°51′	29°28′	28°14′
	Top	9°45′	7°20′	11°59′	8°59′	16°39′	12°27′	19°59′	15°00′
8-in.	Corner	19°06′	17°09′	23°01′	20°41′	30°41′	27°44′	35°51′	32°34′
	Side	16°00′	15°17′	20°15′	18°28′	25°59′	24°52′	30°32′	29°15′
	Top	10°44′	7°50′	12°58′	9°29′	17°38′	12°57′	20°58′	15°30′
6-in.	Corner	21°13′	18°59′	25°08′	22°31′	32°48′	29°34′	37°58′	34°24′
	Side	17°43′	16°56′	21°58′	20°07′	27°42′	26°31′	32°15′	30°54′
	Top	11°56′	8°41′	14°10′	10°20′	18°50′	13°48′	22°10′	16°21′

C.A. = Camera Aperture = 1.485 in. × 0.991 in.
P.A. = Theater Projector Aperture Portion = 1.418 in. × 0.7225 in.

Lenticular Screens

Since it is often desirable to be able to move the transparency camera in any direction, it is probable that a symmetrical light distribution pattern will be preferable to an asymmetrical pattern. Two years ago some excellent work was done along this line at the Signal Corps Engineering Laboratory at Ft. Monmouth, N.J.[1] The small mold which was developed at that time by Gerhard Schwesinger was lent to us by the Signal Corps for further experi-

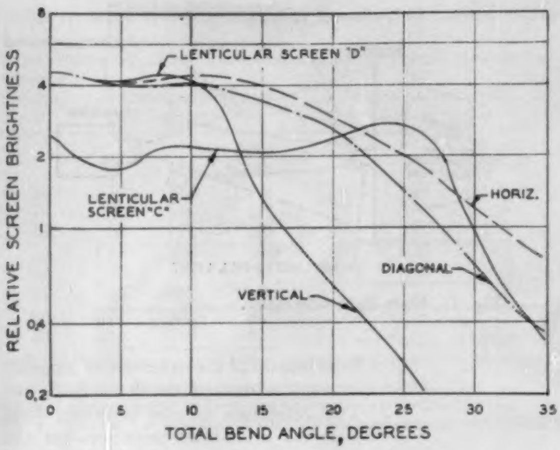

Fig. 8. Screen brightness for lenticular screens C and D.

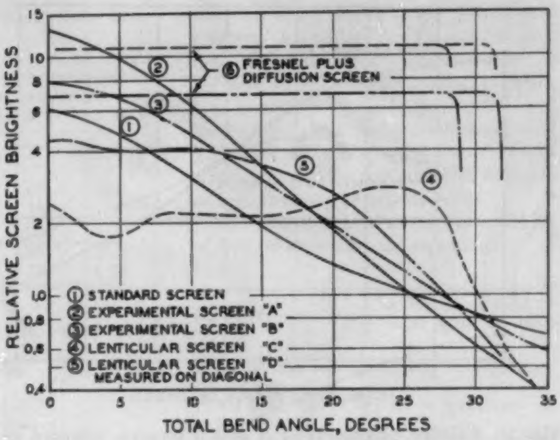

Fig. 9. Relative brightness of standard and experimental sprayed screens, lenticular screens and combined Fresnel-diffusion screen.

mental work. This mold consisted of an assembly of ⅛-in. hexagonal brass rods, clamped together into a larger hexagon about 1 in. across. The end of each small rod had been carefully ground and polished to have the proper aspheric surface. Using this mold as a master, several hundred thin plastic castings were made. These castings were machined on their six edges to the same size and then edge cemented together to make up a screen about 12 in. × 15 in. A photograph of a small portion of the front surface of this screen is shown in Fig. 7.

It is particularly important to note that the surface of this screen has been sanded down to remove all sharp casting burrs between the circular lenticular elements, thereby providing a flat surface between each element. Using a Neoprene printing roller, these flat surfaces were then covered with an opaque black printing ink so that no light would be transmitted through these flat areas. The only areas then operating as image forming elements were the carefully shaped lens depressions. It is quite possible that a similar precaution, if applied to lenticular front projection screens, would considerably improve their definition.

The measured brightness of this Schwesinger lenticular screen C is shown in Fig. 8 as a function of the total bend angle. As calculated, the maximum usable angle is approximately 28°, a value much higher than obtainable with conventional diffusing-type screens. This wide angle makes possible the use of shorter focal length camera and/or projection lenses when used for transparency photography.

As would be expected, a drawback to the edge cemented construction was the fact that each edge shows up as a dark line in the picture. A limited amount of work was done using duplication coating and spraying techniques similar to those described above for Fresnel lenses. Whether this can be satisfactorily worked out on a large scale is not yet known. For motion-picture work it would be desirable to reduce the size of each lenticule from ⅛-in. to a much smaller dimension so that the final screen, with lenticules on one side and a flat surface on the other, would be not more than 0.020 in. thick. The experience gained by duplicating the 0.005 in. wide grooves of the Fresnel screen indicates that it can probably be done with small lenticular depressions. The individual lens elements should also be smaller than ⅛ in. in order to retain the high definition of the double-frame picture projected on the screen. While the lenticular screen would normally be expected to find service in large sizes, it would occasionally have to be used with the camera at close distance where ⅛-in. lens elements would show up.

A still wider angle lenticular screen could be made by using higher index material. Angles up to about 35° appear to be theoretically possible if a suitable plastic can be found.

If asymmetrical lenticular screens are made, a wide horizontal and narrow vertical pattern is obtained. An example of this is illustrated in Fig. 8, screen D, which was made in an 18 × 24 in. size by the Farrand Optical Co. This particular screen was made of molded Lucite about $\frac{1}{16}$ in. thick and contained about 5000 ellipsoidal lenses per square inch. One of the most important problems faced in the making of large lenticular screens would be the accuracy required in the making of the master mold and the difficulty of joining the sections together so that the seams would not show with transmitted light. The problem of the seams will probably be somewhat less for TV use because the seams can be horizontal, blending in to some degree with the horizontal scanning lines.

Symmetrical Diffusion Type Screens

The third approach to the screen problem was based on improvements in construction of the more conventional diffusion-type screens. The main objective was to improve the brightness at total bend angles of 15° to 17°, these corresponding to the corner of the double-frame picture as shown in Table I. Many surface treatment experiments were tried and several interesting finds were made:

1. It was possible to nearly double the brightness at 17°.
2. Some control could be exercised on the amount of hotspot obtained.
3. The amount of front flare light could be materially reduced.

Figure 9, Curve (1), shows the brightness curve for the standard type of transparency screen that had been used for many years. With our new triple-head projectors operating with the 16mm yellow-flame carbons at 230 amps, sufficient brightness was obtained on a 28-ft wide picture to rephotograph to Eastman Color Negative Type 5248 using a 100mm lens on the double-frame camera at $f/4$. This 28-ft width has been the limit of screen size that could be properly illuminated in color and the aim was to at least double this illumination so that we could use either a larger screen, or stop the camera lens down further to carry more depth of focus, or be able to use shorter focal length projector and camera lenses.

This development program with the Stewart-TransLux Corp. was highly successful as indicated by the brightness curve for the experimental Hi-Trans screen A shown by Curve (2) in Fig. 9. The new screen owes much of its efficiency increase to a reduction in the amount of internal diffusion used and changes in the surface treatment which give a wider angle spread to the transmitted beam of light. Another marked

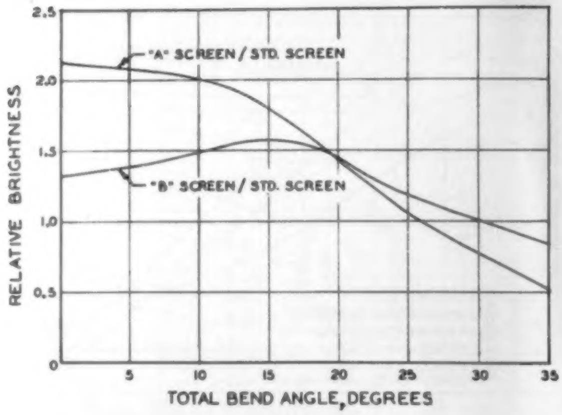

Fig. 10. Relative brightness of A and B screens, referred to standard screen.

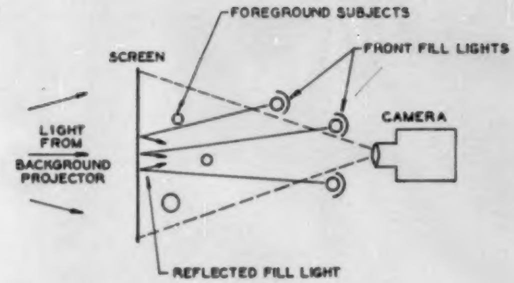

Fig. 11. Flare light schematic.

advantage of the new screen was the reduction in flare on the camera side of the screen. The effective flare was cut in half, which means that contrast will remain high even in the presence of considerable amounts of front spill light. The new Hi-Trans screen A appears as a dark gray on the stage, while the regular screens look bright white.

The response of the new Hi-Trans screen A, referred to the Standard screen, is shown by the top curve in Fig. 10. *The average response is approximately twice as high and this has been completely confirmed by photographic tests with color film. The picture quality was sharper and the contract was higher.*

The doubling of average screen brightness with the new Hi-Trans screen A indicates that we can now increase our maximum transparency screen width from 28 ft to 40 ft with the camera still operating at $f/4$ on Eastman Color Negative Type 5248. There is rarely a need for pictures larger than 40 ft and since this size requires fairly long projection throws, our next objective is to increase the bend angle from 17° to 25° or 35° so that we can shorten the projection throw and use large screens in more limited quarters.

A second experimental screen B is also shown on Fig. 10, compared to the standard screen. This screen has a higher brightness than the standard screen for all angles up to about 30° and shows a remarkable control of the hotspot at small angles. The plot of its brightness curve is shown on Fig. 9.

On Fig. 9 are plotted the brightness curves of all the experimental and standard screen types described above. Each type of screen can be used in many ways, depending on the amount of hotspot elimination used in the projectors, the focal lengths of the camera and projector lenses, the desired depth of field, etc. The brightness of the projected light from the triple-head projectors has also been designed so that it increases about 30% from the center to the corner of the picture. This aids in evening out the screen illumination, particularly for the case of diffusion screens.

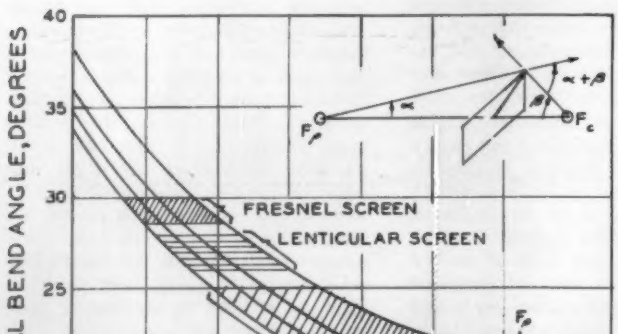

Fig. 12. Approximate operating regions of various screen types vs. bend angle and associated camera and projector lenses.

Flare

Figure 11 shows in schematic form the manner in which flare is created at the surface of the transparency screen. It is necessary to front light the foreground objects with lights that are just outside the camera angle and there is no way of goboing these lights to prevent their shining directly on the face of the screen. With many screen surfaces which we have tried there was a marked reflection back to the camera. The new A screen has very much less reflected flare light back to the camera than the standard screens formerly used. This reduction in flare light has been achieved by a reduction in the internal diffusion of the screen and changes in the surface treatment. The A screen appears as a dark gray on the stage compared to a fairly bright white appearance for standard screens. *This marked reduction in flare light made a desirable increase in the contrast of the rephotographed picture.* Lights to the side and top of the foreground subjects can generally be goboed to prevent light spilling on the screen. In the case of lenticular screens it is particularly important that accurate control of the spill light be maintained.

Bend Angles

On Fig. 12 the total bend angles are plotted as a function of the focal length of the camera lens, for projection lenses varying from 6 to 12 in. The general operating regions are outlined for the standard and experimental sprayed diffusing screens, the lenticular and for the Fresnel screens. All of these are capable of being used at higher angles, either by change of design or operating procedure.

Stage Working Distances

From a stage planning standpoint it

Table II. Stage Working Distances Required vs. Screen Width for Several Lens Combinations and Screen Types.

Screen width, ft	100mm camera lens & 12-in. proj. lens			75 mm camera lens & 12-in. proj. lens			100mm camera lens & 6-in. proj. lens		
	C_F	C_P	$C_F + C_P + 27$	C_F	C_P	$C_F + C_P + 27$	C_F	C_P	$C_F + C_P + 27$
14	37	114	178	28	114	169	37	57	121
18	48	146	221	37	146	210	48	73	148
22	58	177	262	45	177	249	58	89	174
26	69	210	306	53	210	290	69	105	201
30	80	244	351	62	244	333	80	122	229
34	90	275	392						
38	101	307	435						
42	111	339	477						

—— "A" Screen
- - - "Standard" Screen } Camera lens @ $f/4$

C_F = Distance from camera to transparency screen.
C_P = Distance from projector to transparency screen.
$C_F + C_P + 27$ = Distance from wall back of camera to wall back of projector.

is always important to know what the required distances are between the camera and the transparency screen and from the screen to the triple-head projectors. In Table II these distances are listed for double-frame projected screen widths from 14 to 42 ft for three camera and projector lens combinations. The third column for each combination is the sum of the first two columns plus 27 ft. Approximately 20 ft of this distance is required for the triple-head projector and its associate arc grids, while about 7 ft is required from the camera lens to the back wall.

Height of Field at "Near Limit" of Focus

In transparency photography it is necessary that the picture on the screen be kept sharp. This requires that the screen be located at the "far limit" of acceptably sharp focus. The camera will then be sharply focused at some distance in front of the screen, and subjects can approach the camera to at least the "near limit" of acceptably sharp focus.

A plot of the relative image distortion on the film as a function of subject distance from the camera is shown by the solid line on Fig. 13. This distortion takes into account both the film and lens characteristics and has been calculated here for a 100mm camera lens operating at $f/4$ since this is a frequently used setup with a 25-ft wide color picture. Assuming that the picture perspective and the depth and width of subject material in the foreground area require a 25-ft wide transparency picture, we find that the foreground area from 37 ft from the camera to the screen 67 ft away would normally be usable in good focus. Subjects approaching the camera closer than 37 ft would appear in softer focus. For the 25-ft width of picture referred to, the "effective" height of the photographed field of view as finally projected in the theater with a double-frame print would be approximately 13 ft at the position of the transparency screen. The dashed line on Fig. 12 shows the linear reduction of this effective height of field for objects that are closer to the camera. At the "near limit" of focus at 37 ft the height of field would be about 7 ft for this condition, which would mean that we would see all the height of a 6 ft person with a foot of clear height above and below him.

It would be desirable to have the actors approach much closer to the camera while still remaining in sufficiently sharp focus and still retaining all of the background area and screen in focus. This will only be possible when either much brighter light sources are available for the transparency projectors, or when wider angle and highly efficient lenticular or Fresnel screens are perfected. At the present time, if we wish to get a closer shot of an actor, it is necessary to eliminate much of the background and foreground area, and generally move the actor closer to the screen to meet the requirements of depth of field that can be kept in focus.

The height of field at the "near limit" of focus is shown by the equation:

$$H_n = W_e \frac{\dfrac{n}{R_t}}{1 + \dfrac{2Mfd}{F_e}} = \text{Height of field at "near limit" of focus}$$

W_e = Width of projected transparency picture,
n = Fraction of W_e to be projected in theater,
R_t = Aspect ratio picture to be projected in theater,
M = Magnification of projected transparency picture,
F_e = Focal length of camera lens,
f = f/Number of camera lens, and
d = Diameter of circle of confusion.

This expression takes into account the portion of the entire projected picture area on the transparency screen that will be finally used in the theater, the width of the projected transparency picture and the focal length, f-number and assumed diameter of the circle of confusion of the camera lens.

It is also of interest to relate the height of field at the "near limit" of focus with the required camera lens f-number for

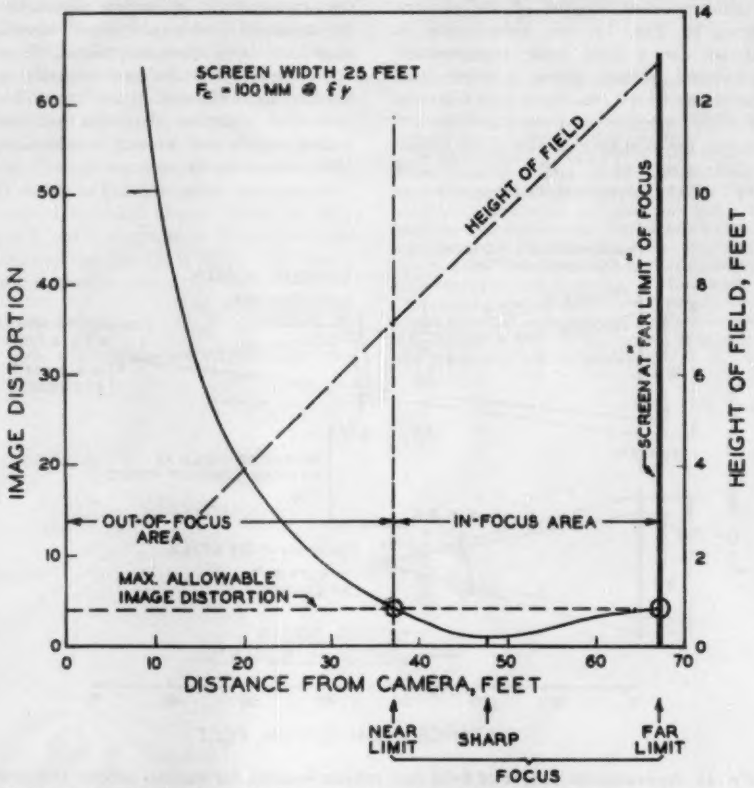

Fig. 13. Image distortion and height of field vs. distance from camera.

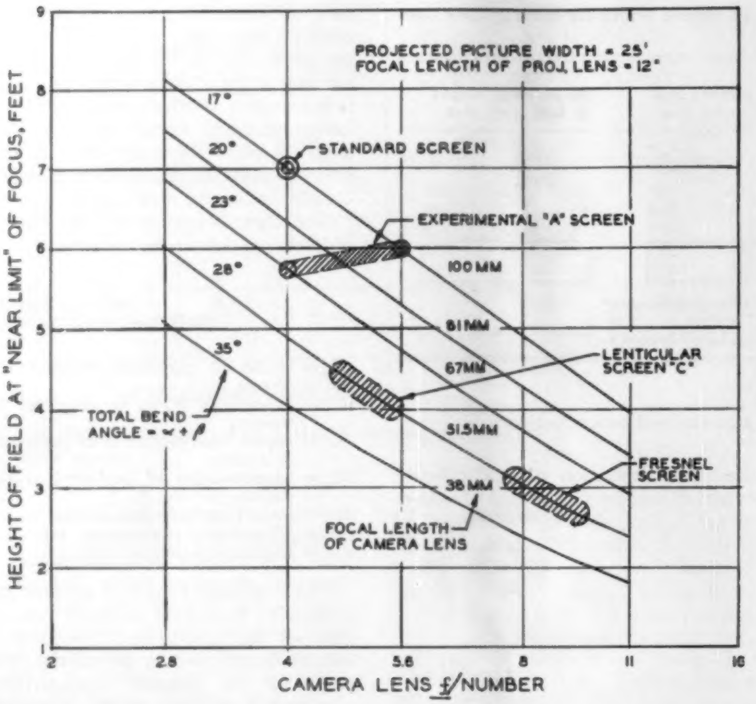

Fig. 14. Height of field at "near limit" of focus vs. camera lens f-number and various types of screen and bend angles.

various types of screens with their related total bend angles and the corresponding focal lengths of the camera lens. In Fig. 14 this information is shown for a 25-ft wide transparency projected picture, using a triple-head projector with 12-in. focal length lenses. For convenience asymmetrical lines are drawn for total bend angles at the corner of the screen of 17°, 20°, 23°, 28° and 35° which correspond to camera lenses of 100, 81, 67, 51.5 and 38 mm. Superimposed on this grid are indications of the approximate operating region for the standard and experimental screens that have been discussed above. These operating regions are not actually as narrow as indicated since there are numerous variables that can be controlled which will have a considerable influence on the operating area.

In the case of the lenticular screen C using Plexiglas we are, of course, rigidly limited to the 28° maximum bend angle. The significant aspect of this plot is the manner in which it indicates how much more dramatic close-ups can be obtained by change of screen structure. It is also important to note that with the camera operating at *f*/4 we require an incident key light of approximately 800 ft-c. Therefore, with more efficient screens operating at *f*/5.6, foreground key lights of 1600 ft-c are required while at *f*/8 we would need approximately 3200 ft-c. At the present time, this is about as high a key light as can be conveniently used without discomfort to the actors. A development program is now under way on stage lighting units which should considerably reduce the amount of heat now projected down to the stage from incandescent light units.[2] If this program is successful it will make operation of the camera at *f*/8 much more comfortable.

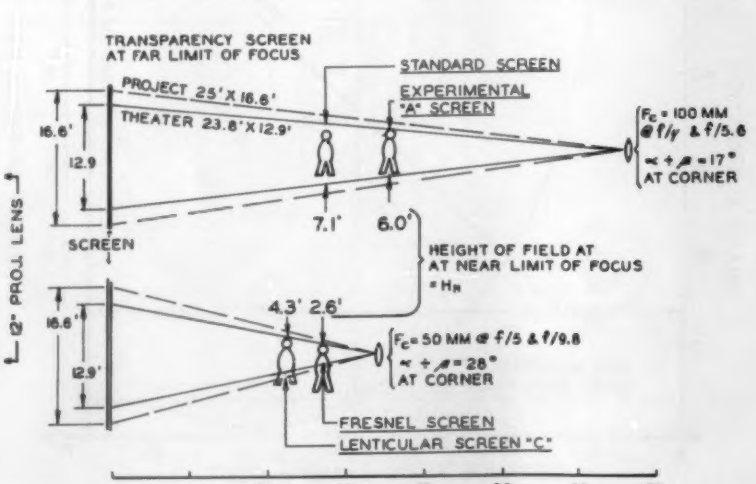

Fig. 15. Approximate height of field and subject location for various screen and lens combinations.

In Fig. 15 the effective height of field is diagrammed for maximum bend angle at the corner of the screen of 17° and 28°, which require 100mm and 50mm lenses on the camera. A 25-ft wide transparency picture has been assumed and the solid ray lines indicate the height of picture that will ultimately be projected in the theater for various distances from the camera. The small outlines of people are drawn to a scale 6 ft high and they are located in each case at the "near limit" of focus for the particular lens combination depicted. The closer the people are to the camera, the larger they will appear as a close-up superimposed on the picture projected on the transparency screen in the background. Four conditions are shown: (1) the standard screen; (2) the experimental "A" screen; (3) the Schwesinger Lenticular Screen C and (4) the Fresnel screen. It is obvious that a more dramatic close-up can be obtained as the person approaches the camera. Four pictures of Moses in *The Ten Commandments* (Figs. 16, 17, 18 and 19) have been artificially assembled to illustrate this point. The background is the same size in each case while the foreground figure has been changed in size by enlarging a still negative to correspond in height and position with the figure positions shown in Fig. 15.

Background Projection in TV Studios

Transparency background projection on live TV shows poses a number of problems which are not encountered in normal motion-picture production. Possibly the most serious of these problems is the limitation in space in many of the studios, which requires the projector to be quite close to the screen. It is frequently desirable to have the distance of the projector lens to the screen approximately equal to the width of the screen. Using the angle nomenclature

Fig. 16. Standard screen, 100mm at f/y.

Fig. 17. Experimental A Screen, 100mm at f/5.6.

Fig. 18. Lenticular Screen C, 50mm at f/5.

Fig. 19. Fresnel + Diffusing Screen, 50mm at f/9.8.

of Fig. 5 and a screen aspect ratio of 4:3 this leads to an angle α at the corner of the screen of approximately 32°. If the live TV camera is equipped with a 90mm lens, creating an image with a 1.6-in. diagonal, we find that the angle β between the camera lens and the corner of the screen is 12°45′. This means that the total bend angle $\alpha + \beta$ equals 44°45′. In order to obtain a reasonable flat brightness curve over this wide an angle, the TV screens are now being made of latex or specially treated Vinylite.

The relatively low brightness of these screens is offset by a very flat brightness distribution curve and since the TV system has a relatively high sensitivity, rear projection is practical. Since this paper is devoted to the study of high efficiency screens for motion-picture studio rear projection, data are not included on the brightness curves of the special TV screens. It does appear, however, that a perfection of the lenticular screen would be of distinct advantage for both TV and motion-picture uses. Two types might ultimately be needed with about 25° and 45° half angles.

It must be borne in mind that the position of the camera must not be extremely critical when used with transparency on live TV shows since the camera must be capable of being rolled into position, properly lined up and be ready to shoot in just a few seconds.

It should also be pointed out that screens used for TV rear projection can have narrow horizontal seams since the seams are hidden by the scanning lines. For the present, screens for motion-picture use have been limited to the seamless variety. With improvements in seam technique, it may well be that large screens can be assembled with seams without their showing when rephotographed.

Future Development Program

Many experiments have been made with sprayed-type diffusion screens to still further increase the efficiency at angles of 17° to 25°. The A screen described above represents the best result obtained to date.

The lenticular screens offer higher efficiency at wider angles but pose serious construction problems. Since there is a definite and continuing need in both the TV and motion-picture fields for this added improvement it may be desirable for all interested parties to further study possible construction methods that might lead to the construction of such a screen of fairly large size at a moderate cost. The development of such a screen might be undertaken as a joint project by a number of interested groups.

Where the very highest efficiency is desired and where the necessary restriction of camera replacement can be tolerated the Fresnel screen offers marked advantages. The possible construction method outlined above might be adequate but it is certain to be quite expensive and the durability of the thin duplicate screens is unknown.

Acknowledgments

We would like to acknowledge the assistance given in this program by the Stewart-TransLux Corp., the Signal Corps, the Farrand Optical Co. and others who rendered valuable assistance.

References

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2. F. E. Carlson, G. T. Howard, A. F. Turner and H. H. Schroeder, "Temperature reduction in motion-picture and television studios using heat-control coatings," *Jour. SMPTE, 65:* 136–139, Mar. 1956.

Discussion

Earl W. Heister (*U.S. Army Signal Corps.*): Will these new screens still require the use of hot-spot eliminators in transparency projectors, particularly with double-frame projectors?

Dr. Daily: With the new screen with the new double-frame projectors, we will still frequently need hot-spot eliminators in one of the three projectors. The other two projectors will not need hot-spot eliminators. The B screen is an experimental type which has been developed to reduce the transmission at 0°, while retaining or increasing the transmission at 17° bend angle. The special screen treatment which permits this degree of control of the hot-spot is quite interesting and no doubt, in the future, still more effective control will be obtained.

Ion-Exchange Recovery of Eastman Color Developers

By JOHN H. PRIESTHOFF
and JOHN G. STOTT

It is customary to use continuous replenishment in a motion-picture processing machine to maintain a constant chemical composition in each of the processing solutions. This necessitates the mixing of large volumes of replenisher, and the continuous overflow of solution from each machine tank. As the overflow solution is discarded, expensive chemicals are lost. Since developer chemicals constitute a large portion of processing costs, a method of recovering or reusing the developer overflow would result in reduced costs. This paper describes a method of decreasing replenishment costs for Eastman Color Print and Eastman Color Negative developers by recovering overflow developer using an ion-exchange method.

In recent years synthetic, ion-exchange resins in a variety of chemical and physical forms have been produced and and are used in many industries for water purification, product purification, and recovery of chemicals from industrial wastes. These resins are commercially available at nominal cost and may be purchased from several sources.

A synthetic, ion-exchange resin is an organic polymer, bearing attached functional groups that are capable of ionization and, hence, act as exchange sites for ions in solution. Resins may be divided into two general groups, cationic and anionic. Cationic resins have an affinity for positively charged ions, and for this reason are used where cations are to be removed from a solution. Anionic resins have an affinity for negatively charged ions and are used where anions are to be removed from a solution. When both cations and anions are to be removed, both types of resins may be mixed in a single bed or placed in tandem in two separate beds.

Solution-resin contact may be achieved in two ways, batchwise or columnar. Since the latter process was used exclusively for the operations in this laboratory, only this method will be described. The solution to be treated is percolated through a bed of the resin, generally at low flow rates to allow intimate contact between the solution and the resin. While a solution is percolating through the resin bed, the number of available exchange sites gradually decreases. When all of the exchange sites have been occupied, the resin has lost its capacity to retain more ions. The resin then may be regenerated by eluting the sorbed ions with a reagent. After thorough washing with water, the resin is ready for another cycle.

Presented on April 30, 1956, at the Society's Convention at New York, by John H. Priesthoff (who read the paper) and John G. Stott, Color Technology Div., Eastman Kodak Co., Kodak Park Works, Rochester 4, N.Y.
(This paper was received on July 11, 1956.)

Preliminary Photographic Experiments

It is well known that as film is processed, certain functional constituents in the developer, such as developing agent, are consumed or chemically changed and halide ions are released into the developer. The concentration of halide found in developers may vary depending on the history of the developer. Halide ions, in their decreasing order of photographic activity, are $I^- > Br^- > Cl^-$. Since iodide is present in very small quantities and, as will be pointed out later, is completely removed by the resin and since chloride has little photographic effect, the discussion will be confined to the effects of bromide.

To maintain developer activity, the depleted chemicals must be replaced, and bromide ion must be removed from the developer in quantities equivalent to its release into the developer from the film. This is usually accomplished by continuous replenishment* with a solution having a higher concentration of those constituents that are depleted and a lower concentration of bromide. The replenisher, then, functions as a vehicle to restore consumed chemicals and to reduce bromide concentration by dilution. The developer overflowing to the drain has the same chemical composition as the developer in the processing tank. Therefore, valuable chemicals are lost primarily because of the increasing concentration of bromide ion in the solution.

Effect of Development By-Products

In general, most of the laboratories processing Eastman Color films have endeavored to maintain a low level (i.e., 0.5 to 1.0 g/l) of organic development by-products. Although no limits are specified difficulties have been encountered which were believed by many to be due to a high concentration (i.e., 2.0 to 3.0 g/l) of development by-products. Such a situation might arise when processing Eastman Color films in a machine that does not use a continuous replenishment system, but in this case the difficulty would probably be due to an increasing halide ion concentration and not increasing development by-product concentration. The following experiments show that organic development by-products have little effect on the films currently being manufactured.

*R. M. Evans, "Maintenance of a developer by continuous replenishment," *Jour. SMPE, 31:* 273–286, Sept. 1938.

Eastman Color Print Film, Type 5382, was processed in 300-ft increments in 5 l of developer until 3,900 ft of film had been used. The seasoned developer contained 2.5 g/l of development by-products by analysis. After processing each 300 ft, the solution was analyzed and reconstituted to tank formula, and a sensitometric strip processed. Comparison of these strips with strips processed at the same time in fresh developer showed only slight differences.

As further evidence that development by-products are not photographically significant, a more thorough seasoning test was conducted using both Eastman Color Print and Eastman Color Negative Films. Eastman Color Negative pictures were processed in a developer that contained 5.1 g/l of development by-products. Prints were processed in a developer that contained 3.0 g/l of development by-products. The small difference between these pictures and those processed in the recommended manner was easily compensated in printing. This would indicate that an ion-exchange resin with a high affinity for bromide ion was needed in preference to one having a high affinity for development by-products.

Preliminary Ion-Exchange Experiments

Preliminary experiments with ion-exchange recovery of Eastman Color developers were conducted on a test-tube scale using a number of different resins. Both Eastman Color Negative and Print developers were percolated through small columns of the various resins tested, and flow rates for sorption and desorption were determined. Chemical analyses of the effluent developer during a complete sorption cycle were made, and from these data the curves in Fig. 1 were drawn. These are typical sorption curves for Eastman Color Negative developer. The developing agent and benzyl alcohol breakthrough occurs soon after the beginning of the cycle. These components rapidly reach the concentration level found in the influent developer. The breakthrough of organic development by-products occurs somewhat later. Bromide ion breakthrough does not occur until

approximately 25 l of developer per liter of resin have percolated through the column. Bromide ion also reaches its maximum concentration rapidly. Iodide breakthrough does not occur in any significant quantity. From these curves it is possible to calculate the volume of developer that may be percolated through a given volume of resin to obtain an effluent which is suitable for replenisher.

Increasing bromide ion concentration is the reason developer is discarded, and the concentration of bromide ion in the effluent is the factor that determines the maximum developer through-put. The concentration of bromide in the effluent must be equal to that required in the replenisher. The volume of developer through-put is, therefore, calculated using the sorption curve of sodium bromide. This may be expressed mathematically by the following equation:

$$xL = \int_0^y (cdv) + z(L - y)$$

Where L = Liters of effluent needed to obtain x g/l NaBr,

x = Grams per liter of NaBr needed in replenisher,

$\int_0^y (cdv)$ = Grams of NaBr in y liters of effluent,

y = Arbitrarily chosen volume in the portion of the curve where the NaBr concentration in effluent is constant, and

z = Grams per liter NaBr in the yth liter of effluent.

For example, the Eastman Color Negative replenisher used in these experiments required 0.25 g/l of sodium bromide. Figure 2 shows the results of calculating the maximum volume through-put. When the areas of the two cross-hatched sections are equal, no more developer should be percolated through the resin bed.

Similar sorption curves were prepared for Eastman Color Print developer, and the value of L computed for a bromide concentration of 0.95 g/l, which is required for Eastman Color Print concentrated replenisher. Coincidentally, the value of L was nearly the same for Eastman Color Negative and Eastman Color Print developers.

A means of regenerating the resin bed that would result in a "clean" resin was also determined experimentally. Figure 3 shows typical Eastman Color Negative developer elution curves.

As a result of these preliminary experiments, Rohm and Haas Amberlite IRA 400, an anionic resin with a high affinity for bromide and iodide ions, was used for the treatment of Eastman Color Negative developer. Fortunately, the same resin was satisfactory for the treatment of Eastman Color Print developer. This resin, moreover, has substantial capacity for removing organic development by-products.

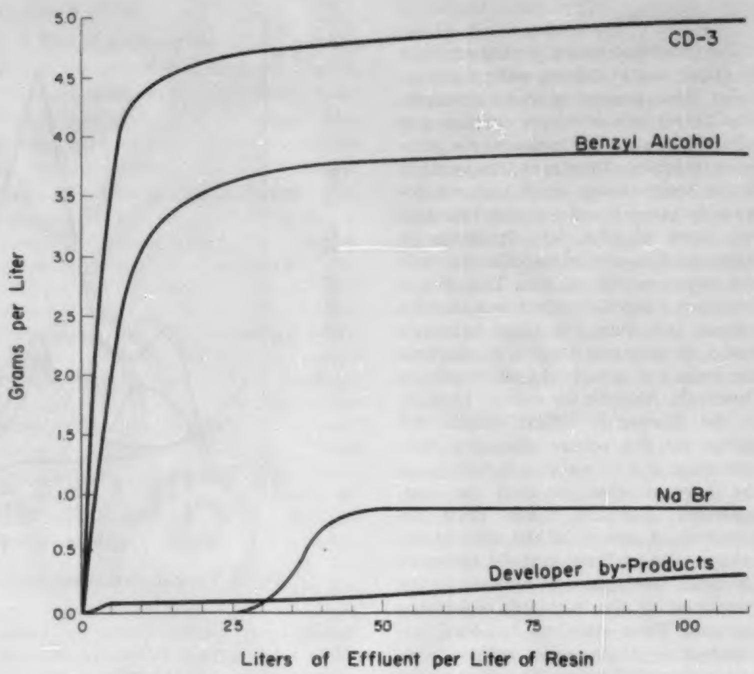

Fig. 1. Typical sorption curves for Eastman Color Negative Developer.

Pilot Plant Equipment

To test these principles, a pilot-plant ion-exchange system was installed through which the overflow developer from a small-scale processing machine was passed. A simplified flow diagram of this installation is shown in Fig. 4. The essential equipment is:

1. A holding tank to collect overflow developer.
2. A head tank which must be at a level which will supply an hydraulic head adequate for the necessary columnar flow.
3. A pump (A) to supply the head tank from the machine holding tank.
4. One or more ion-exchange columns.
5. A holding tank to collect effluent developer.
6. Tanks to hold regeneration solutions.

The processing machine used for these experiments operated at a speed of 25 ft/min. The machine had been processing Eastman Color films using a replenishment rate of one liter per 25 ft/min for both Eastman Color Negative and Eastman Color Print processes. Thus, approximately one liter per minute of developer tank solution overflowed from the machine. This rate of replenishment was reduced to 200 ml per 25 ft/min for Eastman Color Print and 275 ml per 25 ft/min for Eastman Color Negative by using a concentrated replenisher. Hence, the developer overflow from the machine was reduced to about these figures. Cost estimates for the dilute replenisher and the concentrated replenisher systems are shown in Table I.

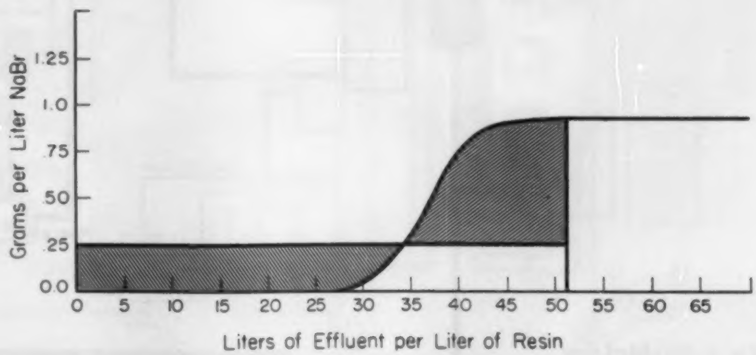

Fig. 2. Curve showing results of calculating maximum volume through-put.

Recovery Procedure

The procedure for recovering overflow developer was as follows, using Eastman Color Print processing as an example: The 200 ml/min developer overflow was collected in a holding tank near the processing machine. Developer was pumped to the ion-exchange head tank on demand by pump A and percolated through two liters of IRA 400, ion-exchange resin at a flow rate of one-fifth the resin bed volume or 400 ml/min. The effluent developer was collected in a tank near the column and when 105 l had been collected, the flow was stopped. At this time the resin was saturated with developer chemicals. Analysis for sodium bromide in the thoroughly mixed effluent developer at this volume showed a concentration of 0.95 ±0.05 g/l, which was the concentration required for concentrated Eastman Color Print replenisher. A sample of the effluent developer was analyzed and the necessary chemicals were added to reconstitute the developer to the required replenisher formula. These additions consisted primarily of developing agent, sodium sulfite and sodium hydroxide. The rejuvenated replenisher was pumped to the replenisher tank by pump B and was ready to be metered into the machine processing tank as needed.

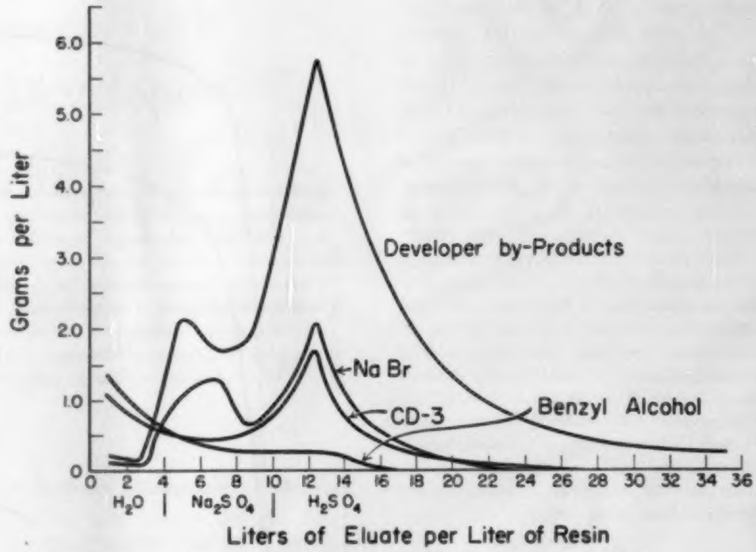

Fig. 3. Typical elution curves for Eastman Color Negative Developer.

Regeneration Procedure A

When the resin became saturated, the small amount of developer left in the column was washed out with water. Then a 5% sodium sulfate solution was percolated through the resin at 400 ml/-min until 10 l of solution per liter of resin had passed through the column. The function of the sulfate solution was to neutralize the resin bed, thus preventing the formation of gas bubbles in the column. This was followed by a 5% (by volume) sulfuric acid solution, which was percolated through the column at 400 ml/min until at least 25 l of acid per liter of resin had passed through the column. The acid desorption removed all of the exchanged and absorbed components and most of the organic development by-products.

The resin, which is originally a yellow-orange color, soon becomes dark owing to the absorption of colored by-products of development. These constituents are only partially removed during regenera-

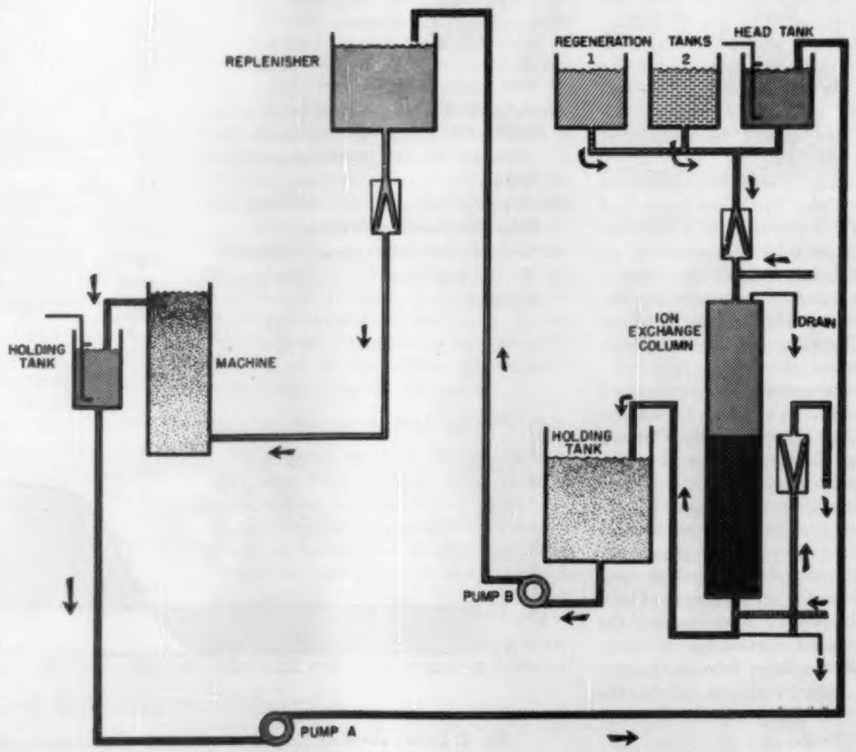

Fig. 4. Simplified flow diagram of installation

tion. After a time, a gradual decrease in bromide capacity was observed. The loss in capacity was not significant until the resin bed had been recycled approximately fourteen times. Since it is essential to maintain a constant bromide concentration in the effluent, it was necessary to treat the resin with different regeneration solutions after the twelfth cycle.

Regeneration Procedure B

The resin was first treated with five volumes of 10% sodium bicarbonate solution per volume of resin. This solution was heated to 125 F and percolated through the resin at a flow rate of 70 ml/l of resin per minute. This was followed by five volumes of a 10% sodium chloride solution per volume of resin. The first volume of sodium chloride was used to displace the residual sodium bicarbonate. The second volume was allowed to remain in the column for four hours. Following this, the remainder of the solution was percolated through the exchanger at a flow rate of 70 ml of solution per l of resin per min. To remove the chloride from the resin and return it to a sulfate form, ten volumes of 5% sulfuric acid per volume of resin were percolated through the bed at a flow rate of 200 ml of acid per l of resin per min. After the acid had passed through the column, the resin bed was backwashed slowly with water and expanded to at least one and one-half times its original volume. The ion-exchange resin bed was then ready for recycling.

Equipment Design

A flow diagram of the actual installation of this machine is shown in Fig. 5. The columns were fabricated from Pyrex glass pipe, 3 in. by 48 in. The column used was packed with two liters of Amberlite IRA 400 ion-exchange resin. The bottom of the column was equipped with a stainless-steel screen, a glass-cloth screen, and a thin bed of gravel to prevent the loss of resin. Developer was percolated through the resin bed twice as fast as it overflowed from the machine tank. Therefore, it was necessary to install liquid-level probes in both the developer overflow holding-tank and in the column head-tank. Both probes were connected to operate pump A. All of the pipes, pumps, filters and tanks used in this installation were standard equipment and fabricated of AISI 316 stainless steel with the exception of the sulfuric acid system. Stainless steel is not satisfactory for holding 5% sulfuric acid. Therefore, the acid regeneration tank and the pipes leading to the column were constructed from Boltaron. However, any other material resistant to 5% sulfuric acid would be satisfactory.

Means were provided for top washing and backwashing the resin. The rotameter at C was used to meter developer down through the column. The rotameter at D was used to meter regenerating solutions. Figure 6 is a picture of the ion-exchange column. This installation is considerably more complex than would be required for a production laboratory since it was desirable to have an installation as flexible as possible to accommodate all experimental contingencies.

The preceding discussion describes the operating conditions which were found most satisfactory for this installation and are not meant to be used as standards. Every processing laboratory will need to perform some preliminary experiments to determine the optimum operating conditions for that laboratory. These experiments need not be lengthy or complex, but the details of operation may vary from installation to installation.

Pilot Plant Experiments

To determine the practicality of the ion-exchange recovery program, it was necessary to process film using a rejuvenated developer. Both Eastman Color Negative and Eastman Color Print films were processed and the overflow developer was recovered using the previously described system. Processing in each case was begun with fresh developer in the machine tank. As overflow developer was collected, recovered, and reused, the percentage of rejuvenated developer in the machine tank increased. Figure 7 represents a plot of footage of film processed vs. percentage of rejuvenated developer present in the machine tank. After processing 210,000 ft of Eastman Color Negative Film, Type 5248, the machine tank contained

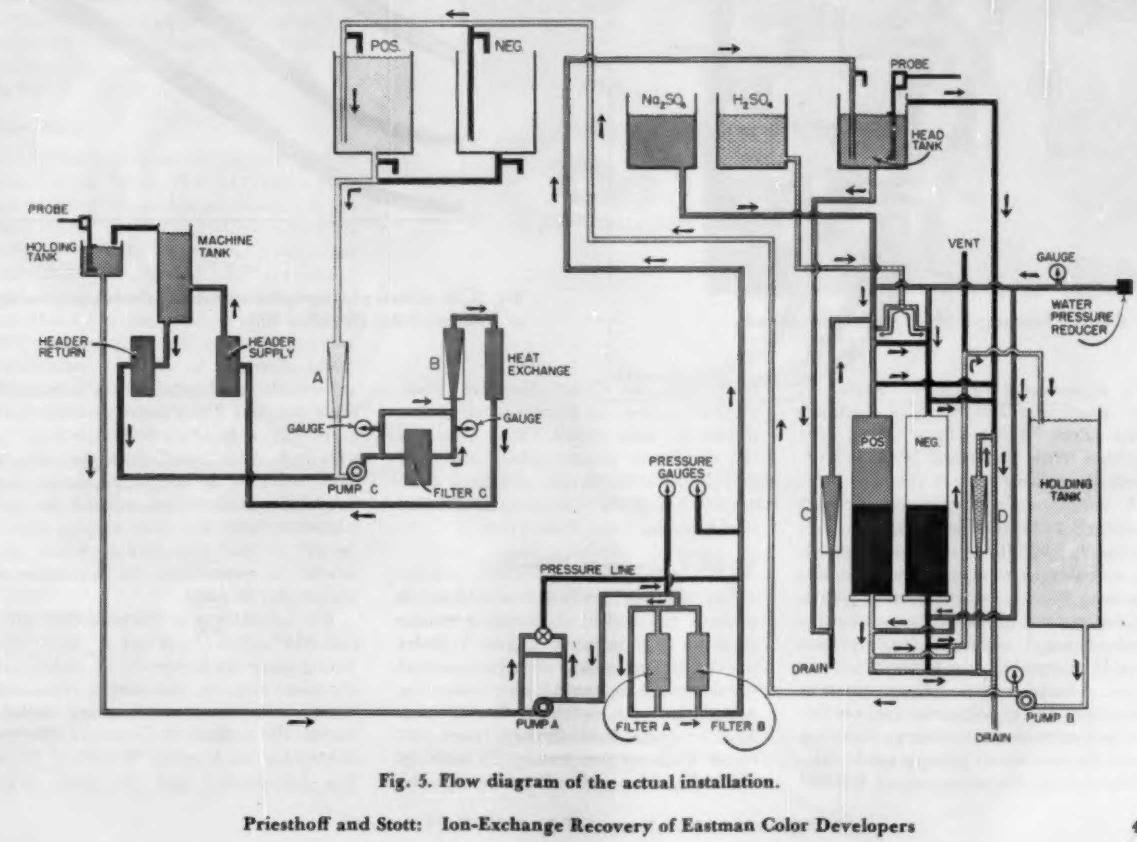

Fig. 5. Flow diagram of the actual installation.

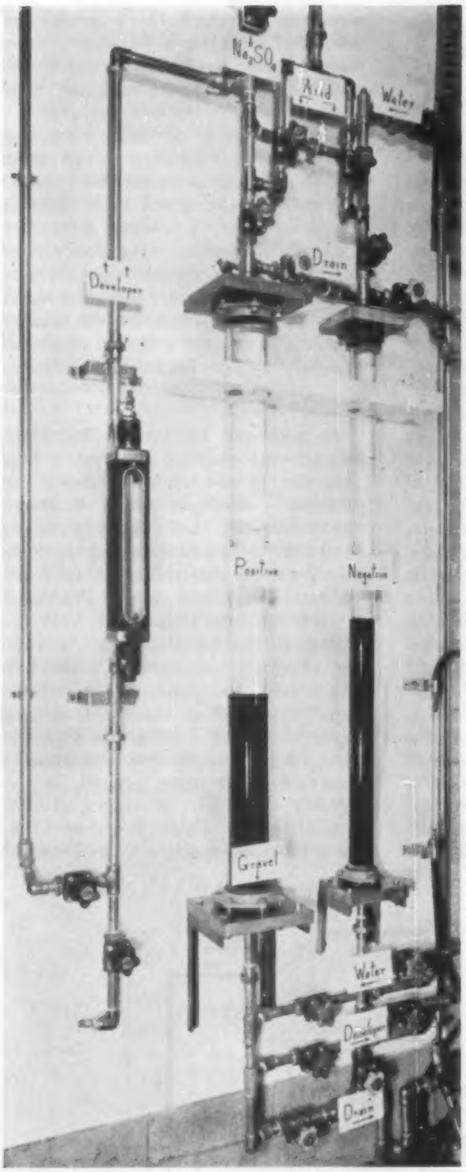

Fig. 6. Photograph of ion exchange column.

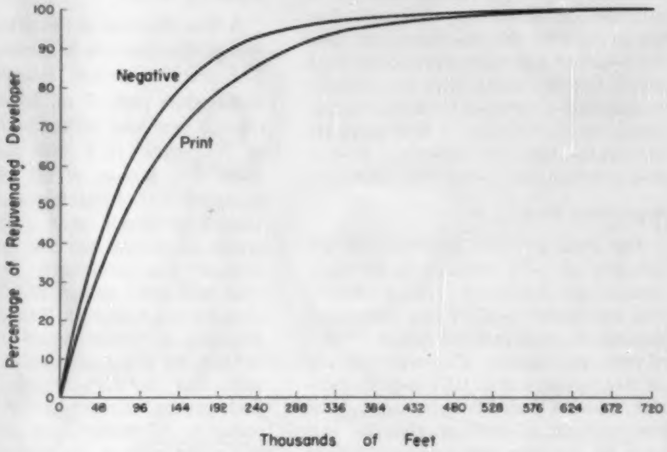

Fig. 7. Footage of film processed vs. percentage of rejuvenated developer.

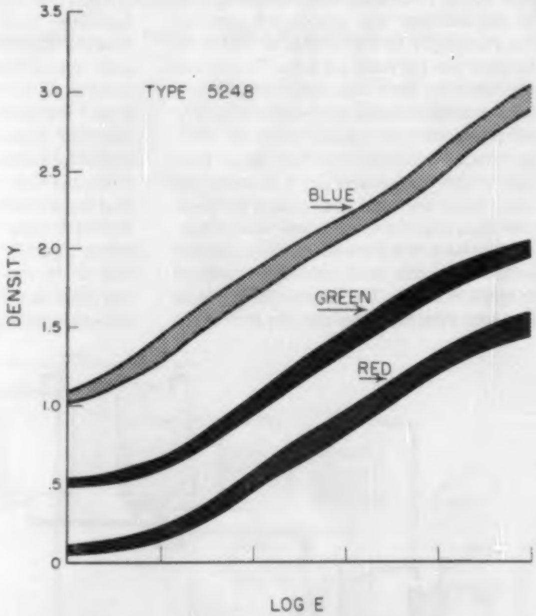

Fig. 8. Maximum photographic variability during processing of Eastman Color Negative Film.

90% rejuvenated developer. Similarly, after processing 270,000 ft of Eastman Color Print Film, Type 5382, the machine tank contained 90% rejuvenated developer.

A sensitometric strip was processed after each 1,000 ft of seasoner film, and after each 3,000 ft of film was processed, the tank developer was analyzed. In this manner, both chemical and photographic control of the process was exercised. Normal chemical and photographic processing variations were observed. Occasionally, the process was chemically out of tolerance and corrective measures were necessary. Figure 8 shows the maximum photographic variability during the processing of 180,000 ft of Eastman Color Negative Film. Figure 9 shows the chemical variability during the same period. Figure 10 shows the maximum photographic variability and Fig. 11 shows the chemical variability during the processing of 230,000 ft of Eastman Color Print Film.

Modified Recovery Procedure

For laboratories whose time or space is limited, a modified developer recovery program may be used. Figure 1 shows the developing agent and benzyl alcohol breakthrough occurring soon after the beginning of the developer through-put. The bromide breakthrough does not occur until approximately 25 volumes of developer have percolated through the column. If the developer flow is stopped after the first 25 volumes of effluent is collected, a bromide-free developer is obtained. Now a sufficient quantity of tank overflow is added to obtain the bromide concentration needed for replenisher. Additions of developing agent, benzyl alcohol and sodium sulfite are needed to reconstitute the developer to replenisher formula.

The advantages of this procedure are: reduced column operating time, reduced space requirements, no additional chemical analysis, and longer resin life. After the necessary preliminary experiments, the volume of developer effluent containing no bromide is known. With this information and the daily tank

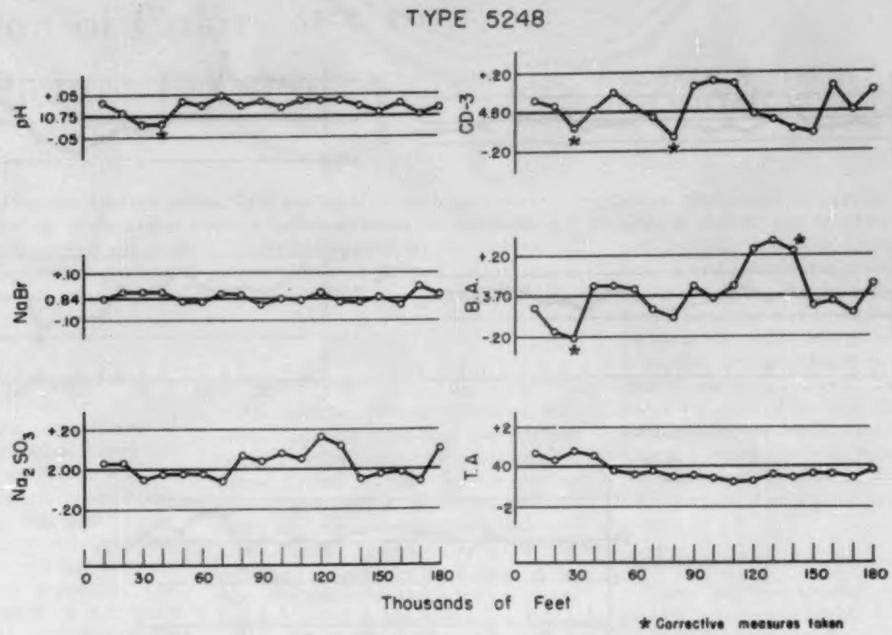

Fig. 9. Chemical variability during processing of Eastman Color Negative Film.

analysis, the volume of tank overflow required to obtain the proper bromide level in the replenisher can be calculated easily. The reconstituted replenisher may or may not be analyzed, depending on the standard practice followed by individual laboratories. This method of recovery is applicable to Eastman Color Print as well as Negative developers.

Cost Data

Chemical costs for developers used in the installation in this laboratory with and without ion exchange recovery of the developers were computed. Chemical cost data were prepared from costs published in *Chemical and Engineering News* by the American Chemical Society on December 26, 1955. Table I shows the approximate cost of developer for processing 1,000 ft of Eastman Color Negative Film and Eastman Color Print Film for four conditions.

Table I. Approximate Cost of Replenisher per 1,000 ft of Film.

	Replenishment rate ml/25 ft/min	
Eastman Color Negative:	1,000 ml	275 ml
No ion-Exchange recovery............	\$3.18	\$1.11
With ion-exchange recovery............	0.37	0.36
Eastman Color Print:	1,000 ml	200 ml
No ion-exchange recovery............	\$1.55	\$0.55
With ion-exchange recovery............	0.37	0.36

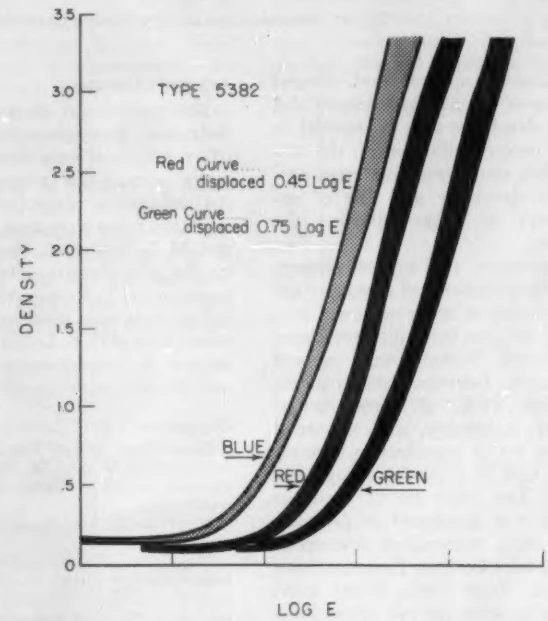

Fig. 10. Maximum photographic variability during processing of Eastman Color Print Film.

These costs may be different in another installation depending upon many factors such as efficiency of film squeegeeing before and after the developer, loss of developer in the ion-exchange system, concentration of the replenisher, and replenishment flow-rate. If the modified recovery system is not used, the effluent developer should be chemically analyzed before it is reconstituted to replenisher formula. This must be considered an added expense in using this method of color developer recovery. While the ion-exchange system operates largely automatically after flow rates have been set, some attention is required during regeneration, startup of a cycle, and shutdown of a cycle. However, less chemical mixing is required since the replenisher need not be mixed but simply reconstituted from effluent developer from the column.

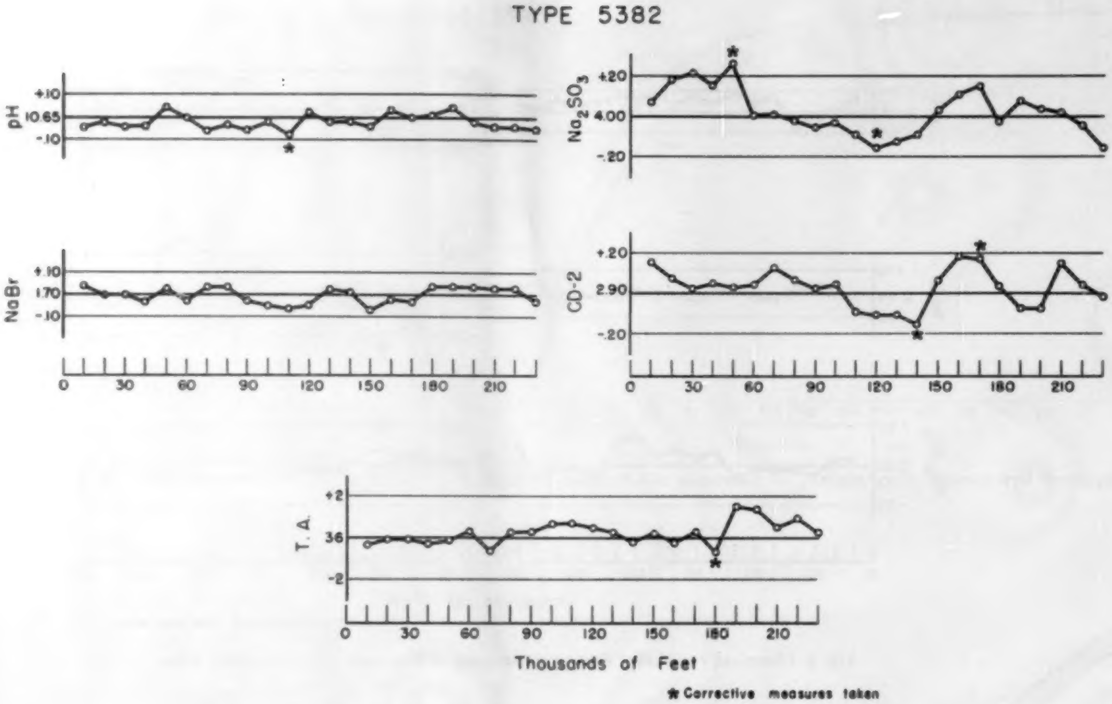

Fig. 11. Chemical variability during processing of Eastman Color Print Film.

It is important to note that efficient squeegeeing of the film as it enters and leaves the developer tank is essential in order to prevent dilution of the developer with water from the rinse preceding the developer and loss of developer into the rinse following the developer.

To demonstrate that motion pictures processed in a rejuvenated developer are equal in quality to those processed in a fresh developer, the following experiment was conducted. Pictures were exposed in duplicate on Eastman Color Negative Film, Type 5248, of three scenes: a high-key, a low-key, and a normal scene. One set of negatives and prints was developed in a process using fresh developer. The other set of negatives and prints was developed in processes using the 90% rejuvenated developers. The prints were both on Eastman Color Print Film, Type 5382. While small differences between the two prints could be seen when they were viewed simultaneously, these were not considered significant, both prints being satisfactory.

Acknowledgments

The authors are deeply indebted to their many associates who, through their effort, help, and suggestions played such major roles in this program. Certain of the laboratory experiments on ion-exchange resins were done by H. L. Rees and M. L. Schreiber. Preliminary plans for the pilot plant installation were prepared by G. T. Keene. All of the chemical analyses were done under the direct supervision of C. B. Lestin. W. R. Weller assisted in interpretation of the data and preparation of the manuscript.

Discussion

Edward Canter (Guffanti Film Laboratories): Was the difference in cost you mentioned only for chemicals, or did you include labor cost for the rejuvenation?

Mr. Priesthoff: The figures quoted were for chemicals only.

Max Kaufman (Consolidated Film Industries): How many times may a batch of resin be cycled; that is, if you start with 100 pounds of resin, what percentage would you have after 50 cycles?

Mr. Priesthoff: As far as the resin itself is concerned, it should, theoretically at least, last indefinitely. During the exchange part of the cycle, the resin becomes saturated with developer ions. Regeneration replaces these exchanged ions with sulfate ions and the resin is then ready for recycling. There is no destruction of the resin in this procedure.

Mr. Kaufman: Is there any tendency for the resin particles to break down so you would get pieces that are too small for practical use?

Mr. Priesthoff: Resin particles do break during use. However, the smaller particles are still capable of exchang ingions. When the pieces become quite small, they are usually washed out of the column during the water-backwash step.

E. W. Heister (U. S. Army Signal Corps): Is it possible or practical to apply this system to Ektachrome-type processing solutions?

Mr. Priesthoff: It is quite possible that Ektachrome solutions could be recovered using ion-exchange resins. Some experimental work is being done with Ektachrome-type developers, but I have no first-hand knowledge of the progress.

Irving Strainer (Pathe Labs, Inc.): Usually after regeneration of an ion exchanger, there is a period of runoff in which the effluent is not collected because of the concentration of regenerating chemicals in it. Is that factor included in the 25-volume figure you have given?

Mr. Priesthoff: The 25 volumes refer to developer that passed through the column. The regenerating solutions had been run off before developer effluent was collected.

Mr. Streimer: You mentioned that after 12 cycles you regenerate with different regenerants. Did this include the typical procedure of backwashing?

Mr. Priesthoff: Yes.

Calibration of Color Motion-Picture Printers

By JACK E. PINNEY
and WILLIAM R. WELLER

Knowledge of the relationship between printer light and log E values is necessary for accurate color timing. Information relating color-correction or intensity-changing filters to log E values is also needed. A method suitable for the calibration of both additive and subtractive motion-picture printers is given.

THE INFORMATION obtained from a printer calibration is essential to any usable method for the color timing of motion pictures. Without a knowledge of the relative log E shifts caused either by changing printer apertures and color-compensating filters in subtractive printing, or by attenuating the red, green and blue light in additive printing, accurate color timing is almost impossible. The fine corrections necessary to achieve a balanced print may be unobtainable because of nonlinearity of the printer scale, unwanted absorption of the color-compensating filters, or variance of the filters from their nominal values due to fading, mislabeling or interface reflection losses.

The purpose of this paper is to suggest a workable procedure for the calibration of motion-picture printers. An attempt will be made to describe some of the common anomalies causing practical difficulties with printers.

Presented on April 30, 1956, at the Society's Convention at New York by Jack E. Pinney and William R. Weller (who read the paper), Color Technology Div., Kodak Park Works, Eastman Kodak Co., Rochester 4, N.Y.
(This paper in revised form was received July 18, 1956.)

Additive Printers

An additive printer combines red, green and blue light into the printing beam. It is assumed in this paper that the filters for an additive printer are so chosen with respect to the position and width of the spectral passband that each film layer is exposed only by its own printing filter over the log E range of the film. For example, an increment of red exposure will then produce an increment in cyan dye alone in the print film. Such a printer usually has provision for independent control of the intensity of each primary color. Intensity timing is usually accomplished by adding the same amount of attenuation for each color. Color correction is accomplished by varying the relative intensity of the light for each of the three colors. A schematic diagram of such a printer is shown in Fig. 1.

Ideally, a plot of relative log E vs. printer light for such a printer is a straight line with equal slopes for red, green and blue as shown in Fig. 2. If the printer has this characteristic, and the desired log E values are known, it is a simple matter to put changes into effect. Only one calibration graph or table is needed, and it may be used for both intensity and color timing.

In actual practice the curves may differ for red, green and blue and the relationship may not be a linear one. Curves for an actual printer are given in Fig. 3. Note that the light change to produce a desired change in log E may be different for each color and different for various intensity levels. Accurate color timing is impossible with such a printer if it is assumed that a given log E change always results from a given printer increment.

Calibration of Additive Printers

There are two general methods of printer calibration which immediately suggest themselves, photoelectric and photographic. Photelectric calibration can be done more rapidly but requires a photocell probe unit such as the light meter for printer control described by Sant, Goddard and Miller[1] that has been carefully filtered so that its spectral re-

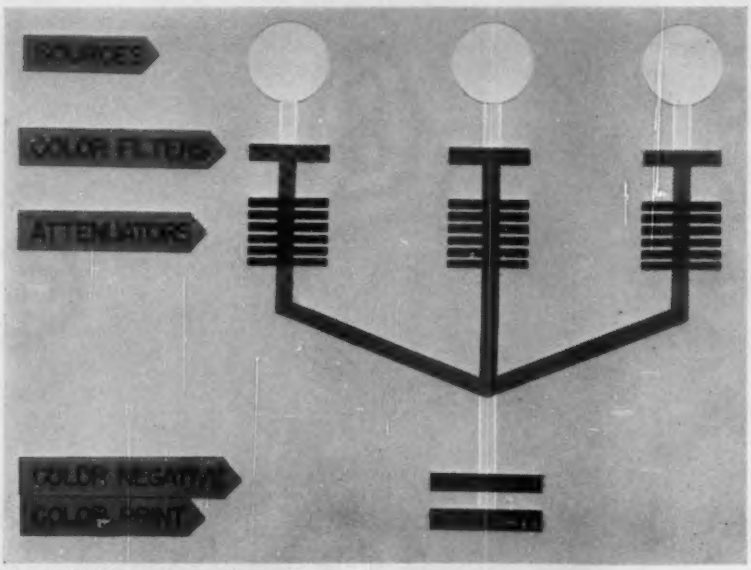

Fig. 1. Additive printer schematic.

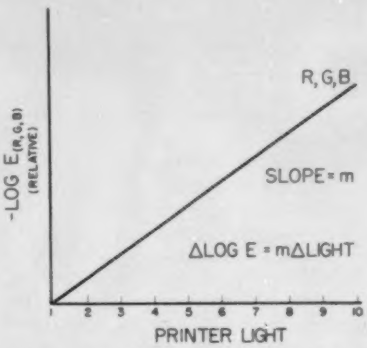

Fig. 2. Ideal printer characteristic.

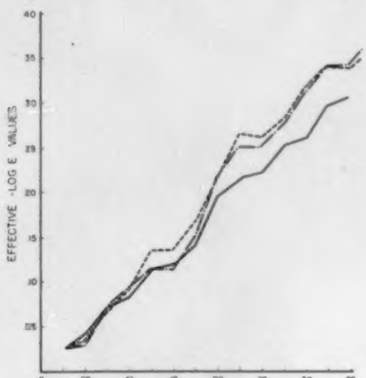

Fig. 3. Calibration curves for an actual printer.

sponse matches that of the print film. If a reliable photoelectric probe unit is available, calibration curves can be prepared by measuring the response separately to red, green and blue, as the printer intensity is varied, and then obtaining the logarithm of these meter measurements and plotting them vs. printer light.

Since printer meters are not in widespread use, a photographic calibration procedure will be described which may be used by anyone who has a color densitometer. A short film loop is prepared which includes a calibrated silver step tablet. Silver scales on black-and-white films may be used for this purpose. A supply of these tablets may be made by exposing Eastman Fine Grain Panchromatic Duplicating Negative Safety Film, Type 5203 or Type 7203, in a sensitometer and developing to a gamma of 1.0 using normal black-and-white procedures. The density increment between steps should be approximately 0.10. The diffuse densities of the silver strip must be known in the red, green and blue regions of the spectrum.

The silver scale is then printed at each printer light in normal progression separately with red, green and blue light, producing cyan, magenta and yellow scales respectively. The cyan dye scales are read on a color densitometer through a red filter, the magenta scales are read through a green filter, and the yellow scales through a blue filter. Density values need only be read through the interval from 0.3 to 1.5. The red densities of the cyan scales (which are actually analytical densities[2]) are then plotted vs. the diffuse red density of the corresponding step of the silver scale. The plot should appear as shown in Fig. 4. It is convenient, but not necessary, for the density increments between steps of the silver strip to be equal. A given density level (between 0.6 and 1.0) is selected. The log E_R displacement between the curves for each printer light is measured at the fixed density level. The data are now available to plot log E_R vs. printer light.

Using analogous procedures, curves may be established for log E_G and log E_B vs. printer light.

Analysis of Results

If the calibration curves, determined by the above procedure, show extreme nonlinearity and/or gross mismatch, some attempt should be made to correct the difficulty. A nonlinear curve will result if the attenuators do not have the proper values. If filters are used in various combinations to produce a range of attenuation in small increments, all of the attenuators must be in accurate calibration to produce a linear relationship between printer light and log E. If several of the filters depart from their nominal values in the same direction, the errors will of course add when they are used in combination. The cyclical nature of the nonlinearity in Fig. 3 suggests the latter possibility.

A typical set of attenuators for one color might have the following density values *including* the effect of interface reflection:

Attenuator Density
0.025
0.050
0.100
0.200
0.400

These filters could be used to cover a log E range of 0.775 in increments of 0.025 and a perfectly linear relationship would exist between log E and printer light.

Since the effect of interface reflection is about 0.036 density units for a clear glass or clear gelatin filter, the 0.025 filter must have a special anti-reflection coating in order to achieve this value. If a coated 0.025 attenuator is not used, all of the filters can be the desired increments of density on clear glass. In this case the maximum log E condition must include the clear glass portions of all the filters. This method has the disadvantage that the maximum amount of light is reduced by the total number of attenuators times 0.036.

It is recommended that all filters be checked on a densitometer before installation in a printer. If the attenuators are selective spectrally, different slopes to red, green and blue will result. This is not a serious matter, but if the three curves superimposed, it would be most convenient. The three (or perhaps one) calibration curves are now ready for use.

Application

It should be noted that all of the preceding has tacitly assumed that the desired change in log E is known. It is not the purpose of this paper to go into detail on this problem, but several methods will be suggested. Log E corrections for additive printing may be obtained as follows:

1. Use of automatic color timing equipment on the negative;[3]
2. Densitometry of a gray card in the negative;
3. Calculation from density differences in the print film, i.e.,

$$\Delta \log E = \frac{\Delta \text{ Density}}{\text{Gamma of print film}};$$

4. By estimation based on previous experience by a skilled color timer.

Subtractive Printing

A subtractive printer is a white-light printer in which color correction is usually effected by introducing color-compensating filters in the beam. Intensity changes are usually made independently either by means of a variable aperture or a traveling matte.

While the production of properly balanced prints using subtractive printers is probably better understood and somewhat more easily accomplished because of the widespread use of scene testers, knowledge of the relation between log E shifts and printer aperture and the effect of various color-compensating filters must be known.

Fig. 4. Plot of intended vs. actual log E_R.

Fig. 5. Relationship between light and log E for Bell & Howell Model D.

The relationship between log E and printer light may be rather easily established by a technique analogous to that previously described for additive printers. Again a silver scale is printed onto the print film at each printer light, although for this case a basic filter pack should be used so that the resulting prints are close to neutral. The resulting scales may be measured through red, green and blue filters using a color densitometer. The red, green and blue densities are plotted vs. the diffuse densities of the silver scale. The log E separation of the curves at a fixed density level again provides a measure of the change in log E between printer lights. Usually the green measurements alone will be sufficient.

For subtractive printers that use apertures to change lights, there is little reason to suspect calibration curves of different slope for red, green and blue. If other means of changing lights are used, calibration curves should also be made from red and blue density data. Figure 5 shows a typical calibration curve for a Bell & Howell Printer, Model D. Note that this curve shows a linear relationship between log E and printer light for most of the curve, but that the curve has a "toe" and "shoulder." Such an effect is not troublesome if these regions lie outside the range of normal interest. It is well to know that the situation exists, however, if printing must be done at the extremes of the light settings.

The greatest problem with subtractive printers lies in determining the log E effect of the color-compensating filters. In the general case, whenever a subtractive filter is introduced into the printer, three log E shifts are introduced rather than one. For example, a cyan filter introduces primarily a log E_R shift, but small log E_G and log E_B shifts are also produced. A worthwhile screening step before performing a color filter calibration for a printer is to measure the filters on a color densitometer. The densitometer should be zeroed on a clear gel and then measurements for red density should be made on each cyan filter, measurements for green density on each magenta filter, and measurements for blue density on each yellow filter. If now the density values are plotted against the nominal filter values for each filter set, a reasonably linear plot should result. Any large departures from the linear plot suggest the replacement of the filter in question. Figure 6 shows such a plot. After any gross errors have been corrected, the photographic calibration may proceed. Again a silver scale is printed onto the color print film at a balance to produce a near-neutral at a printer light somewhat above midrange. A complete filter series is then run for each set of color filters — cyan, magenta and yellow. (The number of filters should be kept constant in the beam while running this calibration.)

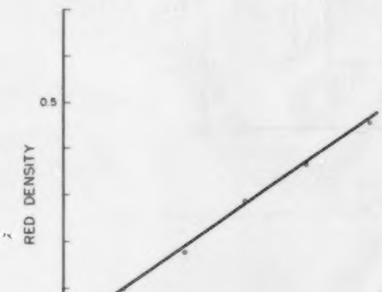

Fig. 6. Check of cyan filters by densitometer measurement.

For each filter set, plots are made of the red, green and blue densities of the color print (over the range 0.3 to 1.5) vs. the red, green and blue diffuse densities of the silver tablet. It would have been desirable to use analytical densities for this part of the calibration, but since analytical densities are not readily available, red, green and blue integral densities were used. The loss in accuracy is not serious in this case. Figure 7 shows examples for a set of cyan filters. Log E displacements between the curves are measured at a fixed density level (here 0.6 density). These log E displacements may then be plotted against the nominal filter value as shown in Fig. 8 for cyan, magenta, and yellow filters. It is obvious from these plots (as mentioned earlier), that a change in a given filter will, in general, change all three log E values. This fact can be expressed mathematically as:

$$-\log E_R = a_{11}C + a_{12}M + a_{13}Y$$
$$-\log E_G = a_{21}C + a_{22}M + a_{23}Y$$
$$-\log E_B = a_{31}C + a_{32}M + a_{33}Y$$

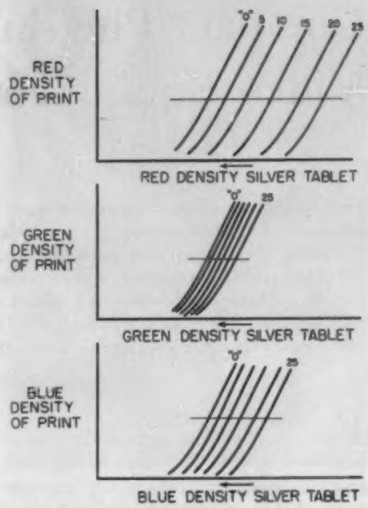

Fig. 7. Plot of cyan filter set — 0 to 0.25.

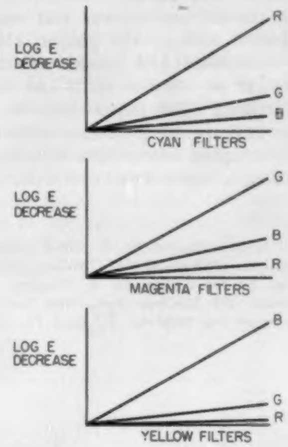

Fig 8. Plot of log E decrease vs. nominal filter value.

The a's are simply the slopes of the various lines shown in the previous figure. These equations may be solved for C, M, and Y so that if the desired log E changes are known, the required values of color-compensating filters may be calculated. The three equations may be solved by use of a slide rule, nomograph, desk computer or more elegantly by use of an electrical analog computer.

In actual practice, it may not be feasible to maintain the same number of filters in the beam at all times. While this requirement is necessary for calibration, adequate compensation can usually be made by light changes. For example, if the normal condition requires three filters, the use of a pack containing five filters would require opening up two printer lights in addition to any other corrections (assuming a nominal 0.05 log E shift for each printer light).

Conclusions

Methods suitable for calibration of additive and subtractive printers have been described. Such information is useful in quantitative and qualitative corrections to color printing. Difficulties caused by errors due to filters, to attenuator values, and the effect of varying the number of filter faces have been described. Such information is essential if any attempt is to be made in improving color timing through the application of instrumental aids. Little has been said about the mechanics of using calibration data in color timing applications. This problem is currently receiving attention and will be reported when the work is completed.

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Compact Plug-in Color Video Equipment

By W. B. WHALLEY

Five new color video components have been developed in the continuing CBS progress toward compact, plug-in television studio equipment. This paper describes the design and operating characteristics of a newly designed color video distribution amplifier, a color video relay switcher and a regulated power supply. These newly designed pieces of equipment are characterized by not only unusual performance but also by their stability, simplicity, quick replacement, ease of maintenance and economy of space.

Five new system components were produced by CBS Television during 1955 in a continuing program to develop compact, plug-in television audio[1] and video equipment. Designed for improved color television performance with fewer parts, lower power consumption and reserve dissipation ratings, the plug-in chassis save rack space and provide rapid replacement of defective units and easier maintenance. This paper describes the design and operating characteristics of a newly designed color video distribution amplifier, a video signal correction amplifier, a pulse distribution amplifier, a color video relay switcher and a regulated power supply.

The CBS 3A Video Distribution Amplifier was developed to provide low differential gain and differential phase with as few parts and also with as low power consumption as possible. In addition to the many other desirable electrical characteristics, the amplitude-frequency response of the amplifier is independent of gain setting. Existing amplifier designs manifest varying amplitude-frequency response with change of gain, which is usually caused by lack of compensating reduction in g_m with increasing cathode circuit control resistance.

The independence of frequency-response with gain was achieved in the new amplifier by combining grounded-grid and cathode-follower circuits in a double-triode and placing the gain control between the two cathodes. Figure 1 is the schematic of this two-tube amplifier. The lefthand section of V1 is a cathode-follower, and this is coupled through the 1000-ohm gain control to the cathode of the second grounded-grid section. The two triode sections have opposite polarity grid to cathode signal voltages, and by choosing suitable d-c plate voltages, the amplitude-linearity is adequate. By returning both grids to the same d-c reference point, there is negligible d-c through the control, hence providing quiet gain adjustment. The same circuit group provides high d-c stability and high tolerance to variations between one tube and another.

Reserve amplitude-linearity is obtained by using a form of "single-ended push-pull" circuit for the output stage,[2,3] where the input and output signals have the same polarity. Because one plate (pin 1) has an opposite polarity signal and is coupled to the second section grid (pin 7), the second plate (pin 9) is closely in phase with the first cathode

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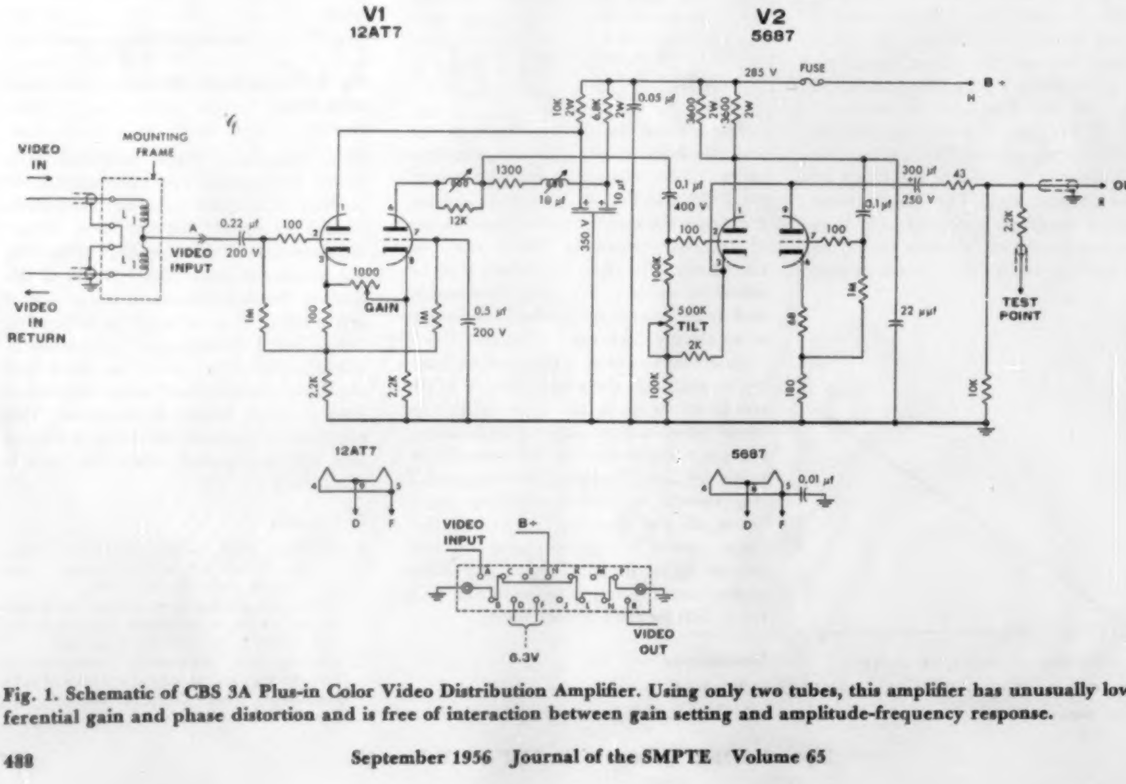

Fig. 1. Schematic of CBS 3A Plus-in Color Video Distribution Amplifier. Using only two tubes, this amplifier has unusually low differential gain and phase distortion and is free of interaction between gain setting and amplitude-frequency response.

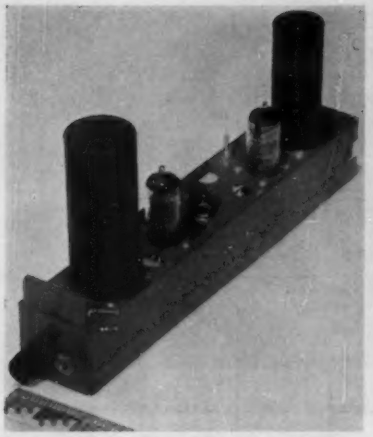

Fig. 2. The CBS 3A Plug-in Color Video Distribution Amplifier.

(pin 3), and 9 and 3 may be connected together. There is very complete cancellation of second harmonic plate current, and the amplitude-linearity in this stage is more than sufficient. The total *differential gain* of both stages is less than 0.4% with a one-volt noncomposite signal.

The circuit capacitances at the first plate (pin 1) and at the second cathode (pin 6) of V2 determine the magnitude and sense of the amplifier *differential phase.* Adding any capacitance between cathode and chassis ground, *increases* the differential phase. Hence, no cathode by-pass capacitor can be used. As the capacitance from the plate (pin 1) to ground is slowly increased, the differential phase decreases to zero, and then increases in the opposite sense. The 22-$\mu\mu f$ capacitor, plus the stray capacitance of the plate-grid circuit, brings the differential phase to less than one-tenth degree with a 1-v peak-to-peak signal level.

Figure 2 illustrates one of these plug-in distribution amplifiers, and Fig. 3 shows a group in a rack mounting frame. Table I is a summary of the operating characteristics showing the excellent performance of this simple two-tube chassis.

Color Signal Correcting Amplifier

The CBS 9A Signal Correcting Video Amplifier was specifically developed to adjust the video, sync, chroma levels and vertical tilt of incoming color signals, without introducing undesirable differential gain or phase distortion. The amplifier is equally useful for correcting incoming monochrome video signals and uses only four tubes. In plug-in form, it is just double the width of the 3A amplifier.

Various forms of video amplifiers named "stabilizing" amplifiers have been tried for correcting color signals. However, the usual stabilizing amplifier employs clipping and reinsertion to control sync amplitude. During clipping, such amplifiers remove part of the back-porch burst signal and introduce nonlinearity in the black region. A large number of tubes and associated parts are also required.

Fig. 3. A group of 24 CBS 3A Color Video Distribution Amplifiers occupies a rack space of 21 in.

The CBS 9A amplifier avoids clipping. Instead the *sync amplitude* is adjusted by automatically changing the amplifier gain in the sync tip region through a biased diode. As shown in Fig. 4, there is a biased 1N34 diode and a series resistor

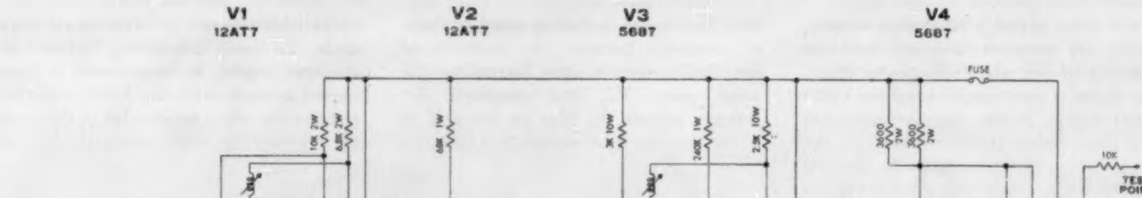

Fig. 4. Schematic of the CBS 9A Signal Correcting Color Video Amplifier. Employing only four tubes, this amplifier adjusts video gain, sync amplitude, chroma level and 60-c tilt without introducing differential gain or phase distortion.

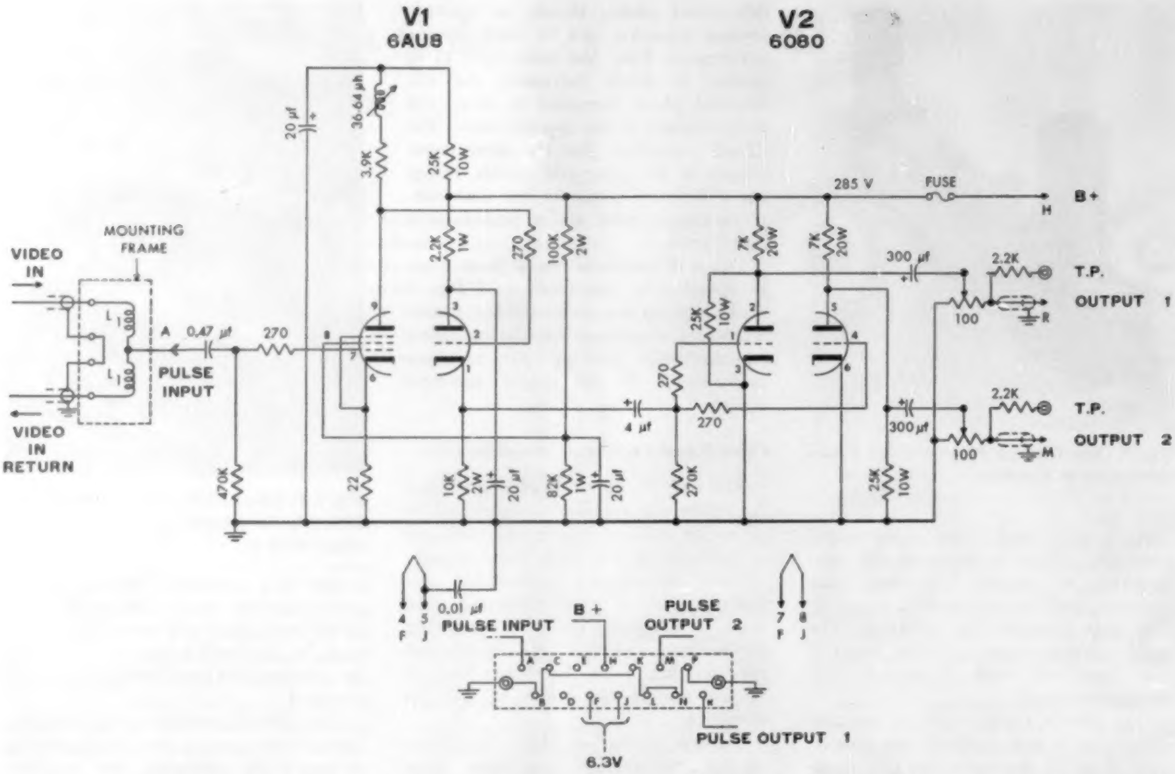

Fig. 5. Schematic of the CBS 8A Plug-in Pulse Distribution Amplifier. Each of the two separate output terminals has an internal impedance of 75 ohms and pulse amplitudes continuously adjustable from zero to 6 v. The pulses are "clipped" on both their tips and base lines.

of 470 ohms across a 1000-ohm resistor, which are situated between the two cathodes of V3, the 5687 power stage. The diode is open-circuit until the video signal swings in the negative direction to a point below the diode bias. As the signal swings further negatively (toward sync tip), the diode resistance decreases to a low value, reducing the net value of resistance between the cathodes of the 5687, and thereby increasing the stage gain. V2, the amplified d-c restorer adjusts the bias on the grid of V3 to hold the sync stretch at a constant value with changes in video signal duty cycle. To avoid amplifying "spikes" in the sync region, a 70-µh choke is connected in series with the 1N34, and this reduces the video bandwidth in the sync tip region. The sync amplitude can be

Fig. 6. The CBS 8A Plug-in Pulse Distribution Amplifier having the same small chassis as the CBS 3A Video Amplifier. Sixteen pulse outputs are available in a rack height of only 7 in.

Table I. CBS 3A Plug-in Color Video Distribution Amplifier — Summary of Operating Characteristics.

Gain Range: 0.4 to 1.8 times (with less than ±1% change in amplitude-frequency response up to 5 mc).
Amplitude-Frequency Response: Flat within ±1% to over 8 mc.
60-Cycle Square-Wave Tilt: ±1%.
Differential Gain: 0.4% } With a 1-v non-composite signal and unity gain.
Differential Phase: 0.1° }
Overshoot: 17% and unidirectional (with 1-v d-c signal).
Power Consumption: d-c = 49 ma at 285 v.
a-c = 1.25 amp at 6.3 v.
Power Stability: Less than ±1% gain change for either:
(a) ±3.5% change in d-c plate voltage.
(b) ±4% change in a-c heater voltage.

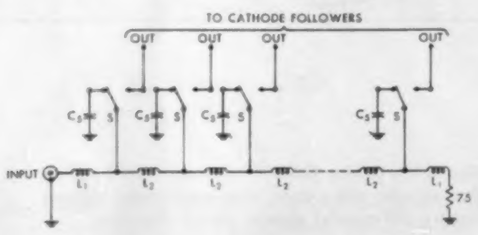

Fig. 7. Schematic of each compensated input line of the CBS 6A Video Relay Switching Unit showing the loading coils L_1 and L_2, the extra switching sections S, and the capacitors C_s. C_s with L_1 and L_2 forms a constant impedance artificial 75-ohm line.

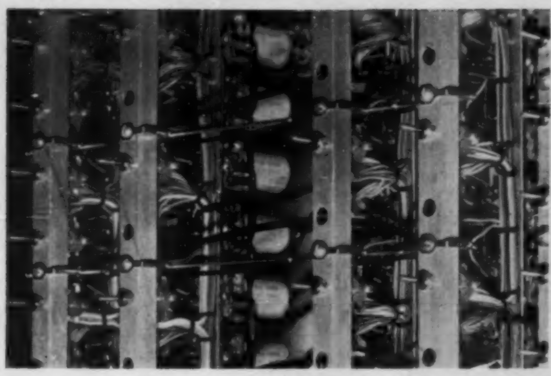

Fig. 8. Assembly details of a 6A Video Relay Switching Unit showing some of the loading coils and relays with their associated video and control circuit wiring.

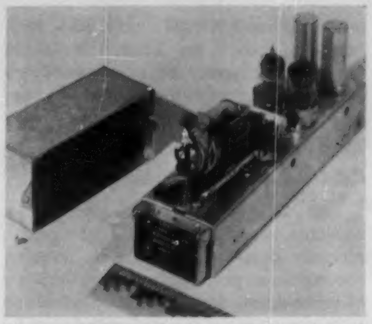

Fig. 9. Plug-in Cathode Follower and Transfer Relay Chassis for the CBS 6A Video Relay Switching Unit. This unit has an overall height of only 3½ in.

increased 40% without affecting the amplitude of the backporch color burst.

As may be seen from the schematic, the input and output stages are identical to the CBS 3A Video Distribution Amplifier previously described. The *gain* control is between the two cathodes of the input double-triode (12AT7). Hence, the amplifier has the same independence of frequency-response with gain setting. The same circuit group provides low differential gain and phase distortion and high d-c stability.

For *chroma level* adjustment, a variable capacitor in the coupling filter of the third stage changes the frequency-response. With the control in mid-position, there is flat amplitude-frequency response; at minimum capacitance, there is a smoothly rising frequency-response reaching +2 db at 3.58 mc; at maximum capacitance, the response falls 2 db at 3.58 mc.

The fourth control (tilt) provides a range of vertical *tilt* adjustment of ±5%, to compensate for any abnormal tilt in the input signal.

Hence, this simple four-tube amplifier makes it possible to correct the usual deficiencies of incoming color or monochrome composite signals. It obviates the need for employing a multi-tube stabilizing amplifier in most situations met in practice and, at the same time, avoids the introduction of differential gain and phase distortion.

Pulse Distribution Amplifier

The CBS 8A Pulse Distribution Amplifier was developed to provide greater output voltage, more rapid pulse rise and more complete pulse clipping than presently available pulse amplifiers. It was also important to have low plate current, low input capacitance and an internal output impedance close to 75 ohms.

A relatively large pulse output voltage (over 6-v peak-to-peak composite blanking into 37.5 ohms) is obtained by using a high perveance triode (type 6080) in the output stage. Figure 5 is the schematic of this amplifier. The pentode section of V1 operates with a screen-grid voltage of only 50 v. Hence, input pulse tip clipping starts at 2.2 v (peak-to-peak). The triode section forms a high level cathode follower and is d-c coupled to the pentode plate. With input pulses of 2.2 or more volts, the grids of V2 are driven with more than 30 v of positive polarity, clipping the pulse base line and providing 6 or more volts of output signal. A d-c current of only 86 ma is required for the two separate output signals.

Figure 6 shows the simple construction and few parts used in this amplifier. It is the same physical size as the 3A distribution amplifier; hence, sixteen pulse

Fig. 10. The CBS Plug-in Power Supply Type 1A Rectifier Chassis, Type 2A Electronic Voltage Regulator Chassis, and Type 3A Electronic Current Regulator Chassis. One rectifier with one regulator unit provides 1.5 amp at 285-v d-c, while the 3A unit supplies reserve current for the focus coil of an image orthicon. This group, for example, forms a complete d-c power package for one monochrome camera.

output circuits are available in a rack height of only 7 in. Thus, this simple two-tube, plug-in amplifier produces clean pulses of up to 6-v. amplitude with reserve tube dissipation and in a very small space.

Color Video Relay Switcher

The CBS 6A Color Video Relay Switcher is a development of the design recently described.[4] Although meeting the rigorous performance requirements of color signal operation, it requires less than two-thirds of the rack space used by conventional monochrome relay switching equipment. As shown in Fig. 7, the objectives were achieved by using video back-contact loading to maintain constant capacitance on each input circuit and by compensating this capacitance with loading coils in each input line.

A specially designed video relay having an open circuit capacitance, between input and output terminals, of less than 0.1 $\mu\mu f$, was used, resulting in low cross-talk. Figure 8 shows a view of a group of these relays with their associated loading coils and compensating capacitors.

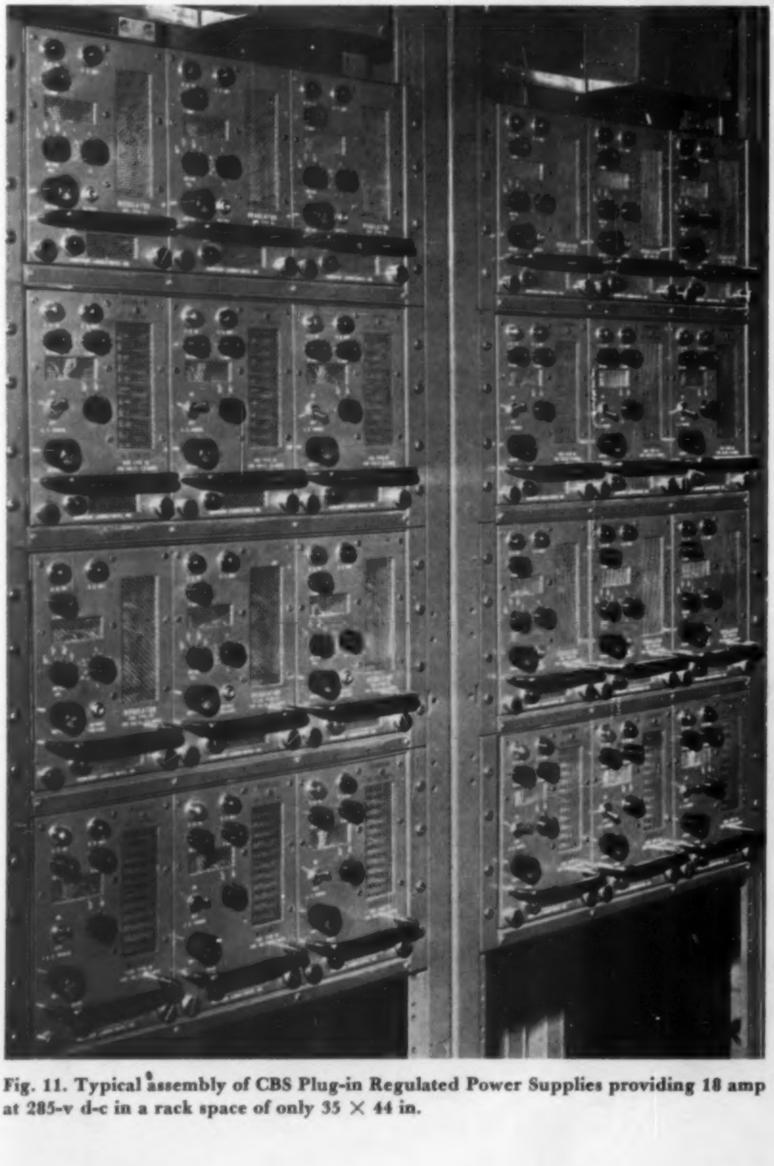

Fig. 11. Typical assembly of CBS Plug-in Regulated Power Supplies providing 18 amp at 285-v d-c in a rack space of only 35 × 44 in.

The switching assembly uses plug-in cathode follower units only 3½ in. high, one of which is shown in Fig. 9.

Six of these CBS 6A relay switchers, varying in size from 12 inputs and 6 outputs to 21 inputs and 10 outputs, have been constructed for the new CBS Chicago Studios. Each switcher, for the most complicated signal routing path, where three cathode followers, three isolation amplifiers, two fader amplifiers and a sync mixing amplifier are all in tandem, has amplitude-frequency response flat within ½ db to over 5 mc, differential gain of ½ db and differential phase of 1°.

Regulated d-c Power Supplies

A new electronically regulated d-c power supply should be mentioned. Whereas all of the above-mentioned devices were developed in the CBS Television Engineering Dept., this power supply was developed by Harrison Laboratories to CBS specifications. It provides 1.5 amp at 285 v and requires only 8¾ in. of rack space, less than one-quarter that taken by conventional units for the same total current. It has a higher d-c efficiency, lower ripple voltage and lower dynamic impedance than conventional power supplies.

Figure 10 illustrates the rectifier and regulator chassis of one of these units, and Fig. 11 a large group of these units. These photographs show the great economy of space and ready accessibility of these units.

Acknowledgments

The author wishes particularly to express his appreciation to A. B. Chamberlain, CBS Television Chief Engineer, and to H. A. Chinn, CBS Television Chief Audio-Video Engineer, for their encouragement and constructive advice, and to F. Sontheimer, who constructed the experimental chassis.

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Report of the Committee on Education

By JOHN G. FRAYNE, *Chairman*

THE Society of Motion Picture and Television Engineers has over a period of years shown a marked interest in educational problems relating to the industry. The first publication in the *Journal* resulting from a formal Society effort was the Frayne report on college courses in motion-picture subjects, which appeared in the August 1946 *Journal*. This was followed later by the Morrison report which appeared in September 1950. As a result of continuing inquiry from students and members of the Society for further information and guidance in the fields of motion-picture and television engineering the Society in 1955 decided to establish a committee on education. This was further formalized by the passage of a constitutional amendment in October 1955 which added to the objects of the Society: "Guidance of students and the attainment of high standards of education."

While the scope of the educational committee is unlimited, early discussions with representatives of studio management, engineering personnel and labor union representatives indicated that the committee should first concentrate on improving the technical training of those already employed in the industry. Secondary emphasis was to be placed on developing curricula in colleges having cinema or allied departments. While this proposal does not augur well for the continuing future supply of trained personnel, it did meet a practical situation dictated by conditions of employment in the industry.

Under the Society's sponsorship, and with the active support and cooperation of union locals, three courses on motion-picture laboratory practice, color duplication and illumination optics were initiated at the Engineering Extension of the University of California at Los Angeles from September 1955 through February 1956. These were followed in the Spring of 1956 by a course in the theory and practice of sound recording at the University of Southern Californi .

Motion-Picture Laboratory Practice

Our belief in the need for this kind of supplementary education and in the desire of those in the industry to keep up to date on technological developments was substantiated by the initial response to, and sustained interest in, these extension courses. More than 100 registered and attended the 18 two-and-a-half hour sessions of the motion-picture laboratory course. The only prerequisite for this $27.00 course was experience in motion-picture laboratory work.

Because of the varying levels of training and experience of those taking all of the courses, material was presented on a practical rather than a theoretical level, using films and demonstrations wherever possible. After a brief introduction and historical survey the laboratory course lectures covered sensitometry, photographic chemistry, laboratory aspects of sound, practical laboratory practcie and color.

No textbooks were used, and the lectures were conducted by: Dr. John G. Frayne, President of the Society and Engineering Manager of Westrex Corp.; William E. Gephart, Jr., Processing Director, General Film Laboratories Corp ; Alan M. Gundelfinger, Plant Administration, Technicolor Motion Picture Corp.; Allen Haines, Chief Chemist, Pathé Laboratories, Inc.; Donald H. Kelly, member of the research staff, Technicolor; and Sidney P. Solow, Vice-President and General Manager, Consolidated Film Industries. At the final meeting of the course, which was an open forum and review, these six sat as a panel to answer questions posed by the students.

Color Duplication

The color duplicating course was conducted by four instructors from the Motion Picture Film Dept. of Eastman Kodak — Robert G. Hufford, Ralph Westfall, John M. Waner and Roderick T. Ryan. Because of the large attendance — 120 registered, and 100 attended 50% or more of the 18 lectures — it was necessary to divide the students into two sections, which met on successive evenings. Students came from the optical departments of most of the major studios and from the laboratories of Consolidated Film Industries, Pathé, General Film, Houston Color, De Luxe, M-G-M and Technicolor. They were required to have experience in printing and/or processing of color motion-picture film plus the consent of the instructors. The fee was $27.00.

The lectures covered the factors contributing to the making of color internegatives through the Eastman Color Negative process, a review of physics of light, filters, elementary sensitometry, fundamentals of color theory, photographic emulsion making, color sensitometry and densitometry, principles of masking in color, description of photographic materials, film dimensional stability, black-and-white and color duplicating, preparation of the duplicate, and variables which affect its quality.

Each lecturer distributed mimeographed sheets covering the high points of his talk. In addition, several reference books and *Journal* articles, as well as a Kodak publication, "Color as Seen and Photographed," were distributed or recommended to the students.

Illumination Optics

The illumination optics course met for two and a half hours each week under the direction of Wilbur Silvertooth, a member of the teaching staff at UCLA. Mr. Silvertooth's lectures covered elements of geometric optics, methods of lens design, elementary theory of lens aberrations, properties of light sources, discussion of specific illumination systems, interference phenomena and filters, and principles of colorimetry. To clarify some of the principles presented in the lectures, the class of 30 students visited the William Mann Optical Co., Monrovia, Calif.

In addition to Mr. Silvertooth, three guest lecturers addressed the students: Dr. Howard Cary and Roland Hass of the Applied Physics Corp. and Dr. Henry Hemmendinger of Davidson and Hemmendinger. The text used was *Technical Optic.*, Volumes 1 and 2, by Martin; and the fee for this course was $27.00.

Sound Recording

Those who planned the sound recording course at USC adapted a course on the regular curriculum of the University to meet the needs of operating personnel in the motion-picture industry. Little emphasis was placed on detailed and precise theory; and mathematics were only introduced when they seemed essential. In every instance theory was related to equipment or apparatus with which the students were already familiar.

Carl N. Shipman, employed in motion-picture sound work in Hollywood for many years and an instructor at the Hollywood Sound Institute, was chosen as the principal instructor. He was supplemented by six guest lecturers from the industry: Thomas A. Carman, Business Representative, International Sound Technicians Local #695; Lorin D. Grignon, Twentieth Century-Fox Film Corp.; Frank E. Pontius, Sales Engineer, Westrex Corp.; Dr. Frayne; Fred R. Wilson, Supervisor, Sound Dept., Sam Goldwyn Studios; and Lloyd T. Goldsmith, Sound Dept., Warner Bros.

One hundred and two attended the first meeting and of this number 84 registered, paying a tuition fee of $60.00 each. Seventy-one of the registrants completed the course which consisted of 16 sessions of 2 hr 40 min each.

A report submitted on August 21, 1956, by John G. Frayne, Committee Chairman, c/o Westrex Corp., 6601 Romaine St., Hollywood 38.

The lectures dealt with present-day recording, methods, materials, equipment and personnel; physical elements of sound and acoustics; production techniques; microphones, mixers and recording equipment; and factors governing sound quality. Extensive use was made of projected diagrams and sketches, and in many instances actual equipment was available for inspection. The lectures were also supplemented by field trips to the Goldwyn and Warner Bros. studios so that the class could compare typical studio installations.

Future Program

Because of the amount of interest in the sound recording course, it is quite likely that it will be repeated. In addition, a more advanced course is being prepared in cooperation with UCLA for the next semester. It will be suitable for those who completed the first course as well as those in the industry who felt that the initial course was too elementary.

Consideration is now being given to have the color duplicating and laboratory practice courses repeated in the Fall semester of 1956.

Under the auspices of Desmond Wedberg there is underway a new study of educational courses being offered in the fields of motion pictures and television. This study should be completed by October 1957 and will be published in the *Journal* as soon as possible thereafter.

Lighting the Network TV Program

By E. CARLTON WINCKLER

Because network programming usually includes greater scope of subject material than is possible on local stations, the lighting of these programs also presents a greater variety of problems. The lighting of larger areas and the variations of this lighting to accentuate a wide variety of moods and camera angles become of paramount importance. The technique developed in lighting network programs uses interesting combinations of all types of lighting equipment and a wide range of wattages to obtain the balance and the intensities necessary for the cameras while operating within the dramatic structure. These techniques and methods are discussed.

So many discussions about lighting for television are concerned with the use and advantages of various types of equipment and control devices that there is a tendency to forget the main purpose of lighting which is to aid in presenting the program in the most effective way possible.

Whether the program is in color or monochrome, the lighting director must be able to visualize the effects to be achieved and to plan their execution. Not only must the lighting director know the technical side of lighting with its extensive range of equipment, performance curves and control devices, but he must also have creative ability which includes understanding of the dramatic values of the program and the skill to use light to help tell the story.

Creative ability is perhaps more important than technical knowledge. Many lighting men of great technical ability are never assigned to important shows because they lack feeling for drama. On the other hand, many lighting men with slight technical knowledge are often chosen for the big shows because of their appreciation of dramatic values and their ability to make light an effective tool in storytelling. It is a fortunate organization that has a man with real understanding of how his craft can best contribute to the final result.

In presenting a story, whether it is a drama, a dance, a song, a stunt, or an illusion, the actor is the center of interest. Other elements, including lighting, only help the actor to convey his meaning more clearly or more quickly.

One of the functions of lighting is to separate the actor from the background. Light on the background should be less bright than that on the actor. He must be placed in proper perspective with the scenic elements and modeled to avoid appearing as a paper cut-out.

A great deal of this separation and modeling is accomplished by the backlight which is directed toward the camera to rim the head, shoulders and arms so that they stand out away from the scenic elements or other background material. Special mention of the backlighting is made because many light men tend to project it at too steep an angle. It then becomes a sort of top light which has no value, causing the forehead and nose to be overlighted and cast unwelcome shadows. Good backlighting must be projected at a fairly flat angle to do the job of making the actor real, believable and important.

In pointing out, modeling and separating, it is essential that the audience can always see the actor's face and especially his eyes. The eyes are the actor's most expressive feature and, if they are just a shadow area, we would be better off as a radio show.

Lighting the face and eyes is best done with the fill-light or with special eye kickers mounted on the camera itself. Occasionally a special hand-held low-wattage floodlight may be required. But, whatever the inventiveness required to get the necessary light in—*light those eyes!*

The next step is to provide the proper mood for each scene in the story. Light can quickly set the mood of a scene. Pages and pages of dialogue or pantomime would be required to set a mood which light can convey to the audience at a glance!

Time and place — morning, afternoon, evening or night; interior or exterior — can be conveyed instantaneously without explanation or delay to the storytelling by properly directed, placed and keyed lighting.

Then there is the highly important matter of providing sufficient light to give adequate video information to provide a good broadcast or recorded picture. Here is where many lighting men meet their Waterloo and many video engineers lose their minds because at this point light men and engineers no longer seem to speak the same language. The moment when a program first goes on camera may well decide whether it is a success or failure — and the right path can only be the result of understanding and cooperation between the light man, the video engineer, and the director.

For example, the light man has set up his scene to the accepted standards of intensities according to his eye, his light

This paper was presented on May 2, 1956, at the Society's Convention at New York by E. Carlton Winckler, Program Dept., CBS Television, 485 Madison Ave., New York 22.
(This paper was received on July 25, 1956.)

meter and his best judgment. But the video engineer's first comment is, "I gotta have more light — it's too dark." That's what he says. But usually that isn't what he means! Many shows have been ruined because the light man accepted "more light!" at its face value and destroyed his whole scene balance in an effort to cooperate as he piled on more and more light. Now what the video engineer really meant was that he had to close down his lens diaphrams because some one spot was too bright for the video system to tolerate, and when this lower exposure could handle the hot spot the rest of the picture appeared underlighted. The experienced light man translates this difference in language, finds the hot spot, and — with the video engineer's cooperation — pulls it down until balance is restored.

Balance is more important in the television picture than intensity. Proper contrast levels permit a good picture to be broadcast. Proper balance between key, fill, back and modeling light permits a good dramatic result as well. Added together, these light elements are the best salesmen for the actor and the other story ingredients.

For the best results, it is better to work at the lowest possible light level practical for good video results. This is true for two reasons: first, the lower level is more flattering to both the actor and his background, helping to disguise blemishes and generally to soften harsh lines. Second, because higher light levels than are necessary force the cameraman to close his lens down — thereby increasing the depth of field. This, in turn, tends to bring the background into sharper focus where it may destroy perspective and separation and distract from the importance of the action.

One of the pitfalls of lighting is shadows. Every solid object in normal life casts a shadow when exposed to light so one shadow is natural. Under the directional light necessary for video photography, this one shadow can be quite a problem because every light source beyond one light causes an object to cast an additional shadow. One shadow is natural, two, annoying, three, distracting, and more, absurd. By the use of diffusing screens, barn doors, projection angles, and other devices, it is possible to keep the shadow singular. Great care is essential in the projection angle of the lights to make sure that the shadow falls in a natural place. After all, noonday or even moonlight shadows are rarely cast upwards. Yet they have often been seen so on TV!

Differences for Color TV

Lighting for color differs from lighting for monochrome in intensity of light required, the shorter brightness range the color cameras can accept, and the ability to use colored light. Instead of an average of 75 to 150 ft-c for monochrome, 250 to 400 ft-c are needed for color. This means either larger wattage instruments or more instruments. Either way, it complicates the shadow problem, with the added hazard that deep shadows with little or no illumination tend to become contaminated with unwanted color because of shading problems in the color cameras. This is apt to make the art director and costume designer a touch unfriendly to the lighting director. By keeping the shadows slightly transparent through the use of a carefully adjusted amount of general fill-light so that some signal is obtained, the contamination of the shadows can be avoided and the shading problem reduced. Larger wattage units (5000w) have proved most successful for key lights while 2-k's work well for back light and modeling light. Carefully diffused 1500- and 2000-w scoops do a fine job as fill.

It is no more necessary to have every color scene brightly lighted than to have every monochrome scene bright. Low key is perfectly practical in color; and shadowed areas in bright scenes (provided, of course, that some signal is available in the shadow areas) do add realism and photographic quality. The good lighting man keeps always in his mind that the natural picture is the right picture and that the story cannot appear sincere or effective if the lighting or any supporting element is artificial or out of key.

Balance is even more important in color, especially as it affects the actor. Overlighted skin tones tend to appear light lavender and to bloom, while underlighted skin appears red. It might be pointed out that in monochrome a brightness range of 30 to 1 can be effectively handled, but in color the brightness range is limited to about 15 to 1.

One of the very real problems of lighting a color show is that everyone in the studio suddenly becomes a color expert and the moment a big name star appears on camera at rehearsal, light adjustment *must* be about perfect or the instructions and suggestions from the experts are enough to drive a lighting man out of his head — or, at least out of show business. For this reason, color lighting should be checked on camera with a stand-in or model before the star arrives.

To assure a natural picture in color, the lighting man will pay special attention to his contrast range, and the evenness of his fill-light to make sure the actor does not wander in and out of hot spots and that shadows remain transparent. He will give added attention to the projection angles of his lights for proper shadow placement and be extremely careful that his back-light does not develop into useless top light. With these precautions, he will be sure of a good quality picture.

Colored Light

Colored light is an interesting and effective tool and is usually uppermost in the mind of a lighting man when he first enters color production. However, there are a number of pitfalls in every colored light and a number of things to keep in mind.

It is perfectly practical to use colored light — any color you desire. The color camera will accept and reproduce it — provided it is of proper intensity. When a color filter is placed in front of a light the quantity of light being delivered to the subject is sharply reduced; therefore more light is required at the source. This will increase the load and the heat generated, as well as the cost of setup and operation. Also, unless glass filters are used, several changes of gelatine filters will probably be required during lengthy rehearsals.

Ordinarily, colored light is best confined to scenic elements and costume highlights. It should be used on the actor only when its source is obvious or visible to the home audience, for example, a campfire, stained glass window or moonlit garden. This procedure is recommended because flesh tone is the only universal guide the home audience has to adjust its receivers. The leading lady's dress may be red or purple, the wallpaper may be gray or pink for all the audience knows, but it does know approximately what skin tone is. Experience has proved that unexplained distortion of skin color causes the audience to readjust their receivers, in which case it is anyone's guess what happens to the other elements of your picture and the only good that can come of it is a sharp upturn in busines for neighborhood set-repair men.

Colored light is effective for scenic elements such as sky cycs and abstract back-cloths, but usually it is less expensive to make the object the desired color and light it with clear light.

Mood, place and tone effects can be as readily achieved with clear (or white) light as with colored light because the lighting elements must be in proper balance of intensities in order to get the effect you desire when the color picture you are sending out is received on a monochrome receiver which is the way the larger part of the audience sees it.

When the lighting director has given video enough level, made the actor the center of interest at the right moments, provided the right balances for mood, place and time and made the scenery look real and the sponsor's products good enough to eat, how can he be sure he has done a good job? His audience will tell him. When the lighting director has done a right job, he will receive the highest compliment a lighting man can wish for when his audience says, "It was such a good show . . . the lighting? Why, I never noticed it!"

Camera Matching and Illumination Control for Color TV

By EDWARD P. BERTERO

In the development of color camera matching techniques it was found inadvisable to use colored paper or other opaque material illuminated by direct front projection. The reasons are: (1) illumination of the test chart is extremely critical in obtaining the exact values of each color chip on a day-to-day basis; and (2) generally, stable color papers do not have the degree of reproducibility in manufacture and the degree of saturation required for precise measurement purposes. A color camera alignment and matching technique has been developed using 8 × 10 transparent slides of both black-and-white and color. This technique required that the source of illumination for the slides be of the proper brightness and spectral response normally encountered on a live set.

The electrical components of the color system used at NBC are aligned by the use of an electronically generated color bar signal. To match the color cameras, however, requires the use of certain test patterns. In aligning a color camera, three monochrome test charts are used, the RETMA Resolution Chart, the RETMA Registration Chart and the RETMA Logarithmic Reflectance Chart (Figs. 1–3). After the cameras are aligned, the next step is to view a live model for color matching. In this procedure, the illumination of the test charts and the model is a major factor in realizing a camera match. As each camera has a different view of the model, color matching would seem to be theoretically impossible because of the difference in reflection from the model as seen by each camera.

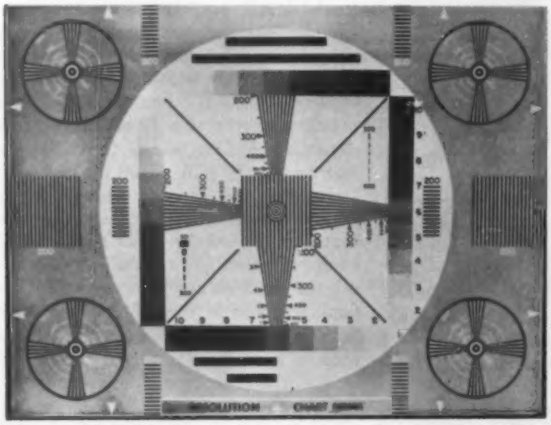


Fig. 1. RETMA Resolution Chart used in color camera alignment.

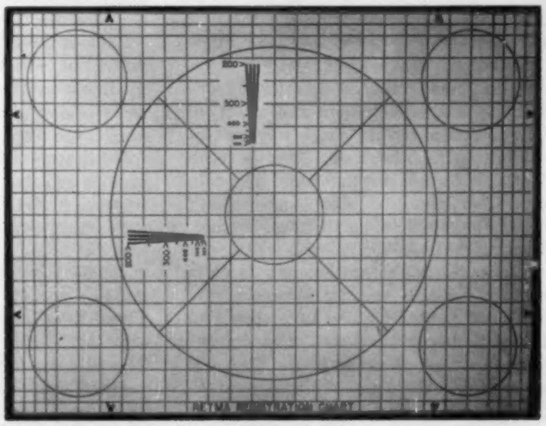


Fig. 2. RETMA Registration Chart.

In an attempt to solve this lighting problem a special shadow box was constructed to contain the test charts. The shadow box consisted of a number of lamps, shielded from view of the camera, which illuminated the test patterns as evenly as possible. For camera matching purposes, the source of color information was obtained by mounting Munsell color papers inside the shadow box. However the shadow box proved unsuccessful mainly because specular reflections from the Resolution and Registration Charts were objectionable and the color signal obtained from the Munsell color papers proved insufficient in hue and chroma for suitable vectoroscope presentation.

Transparent Color Filter

Another unsuccessful attempt was made to solve the problem by the use of a transparent color filter. This method was considered because of the desirability of obtaining high saturation for color matching purposes. Simple tests indicated that the use of transparencies both for the monochrome test charts and for the color test chart might be satisfactory. A family of 2 × 2 in. slides was then prepared. The 2 × 2 in. slides of the test patterns were projected into a color camera and although this method appeared to be a useful means of aligning and matching color cameras, there were serious operational objections. The projection of 2 × 2 in. slides into a color camera by means of either an NBC video announcer or a Back Analyzer requires that both objective and fields lens be removed and replaced each time the color cameras are to be aligned and matched. Since this procedure consumes

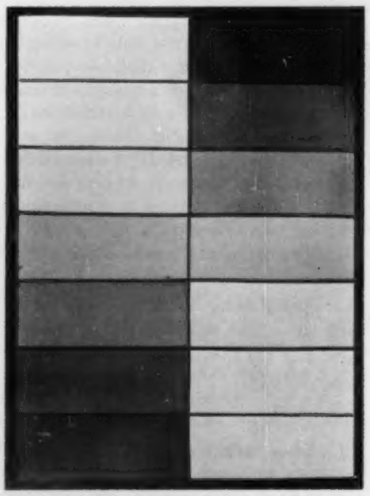


Fig. 3. RETMA Logarithmic Reflectance Chart.

Presented on May 2, 1956, at the Society's Convention at New York by Edward P. Bertero, National Broadcasting Co., RCA Bldg., Radio City, New York 20.
(This paper was received on June 27, 1956.)

a considerable amount of time, the projection of 2 × 2 in. slides into a camera was abandoned.

The third approach to the problem was to rear-project 2 × 2 in. slides to an 11 × 14 in. image. This did not require any manipulation on the camera but there were three serious disadvantages.

(1) Because of lens flare, gray-scale reproductions were distorted.

(2) Ambient light also seriously affected the reproduced image.

(3) Inherent with any rear-projection unit, there was a serious loss of resolution of the test patterns.

The final approach to the problem was to use 8 × 10 in. transparencies. This size was chosen in preference to 11 × 14 in., for the simple reason that 8 × 10 in. is the largest size in which flash density film can be obtained. The

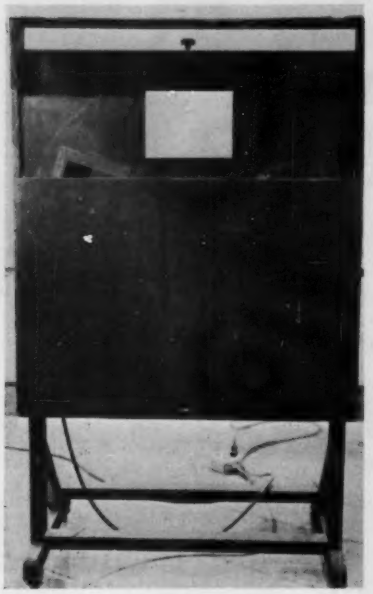


Fig. 4. Front view of ammeter and autotransformer.

8 × 10 in. transparencies of the normally used opaque test charts were made of the RETMA Resolution and RETMA Registration Charts. Since it is almost impossible by ordinary photographic methods to reproduce a gray scale, a gray scale was fabricated by putting together various values of Eastman Kodak flash film in a layout similar to the RETMA Logarithmic Reflectance Chart.

A light source for these transparencies was developed to the following specifications:

(1) The brightness of the transparencies must equal the brightness of the opaque test charts as illuminated in a normal studio procedure.

(2) The light source is to be as diffuse as possible.

(3) A simple means must be provided to easily position the test pattern transparencies in front of the light source.

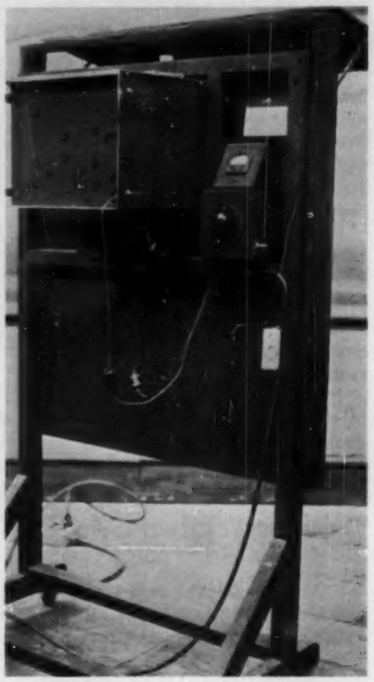
(4) The color temperature should represent the best compromise of the various incandescent fixtures that are used in a normal studio.

The greatest trouble encountered in assembling a light source to meet these specifications was in getting the proper color temperature. Initially, color temperatures were measured of inside-frosted lamps, coated lamps, spot lights, and 110-v lamps used on 120-v circuits. A figure of 3000 K was decided upon as the best compromise for the color temperature for our rear-illuminated transparencies.

The light source that meets the specifications consists of an open-ended enclosure 12 × 12 × 15 in. in which five 60-w "white" 120-v lamps are mounted on an adjustable plate and are located opposite the aperture. The aperture of the light source consists of a diffusing plastic material sandwiched with an Eastman Kodak Wratten #82C Filter. An ammeter and autotransformer (Figs. 4 and 5) are in series with the lamps which, in combination with the diffusing material and Wratten #82C Filter, provide a source of illumination of 600 ft-L at 3000 K.

The use of rear-illuminated transparencies by the Operating Group at the Radio City color studio has been well received. This system of using transparencies lends itself quite readily to the development of an operational technique of camera matching. Preliminary tests using a color transparency approximating color bars has yielded valuable information to match color cameras.

It may also be added that for stations unable to afford the services of a model, that Ektachrome Ektacolor photographs of a close-up of a model as one of the test transparencies of the assembly will serve very satisfactorily as a means of matching color cameras.



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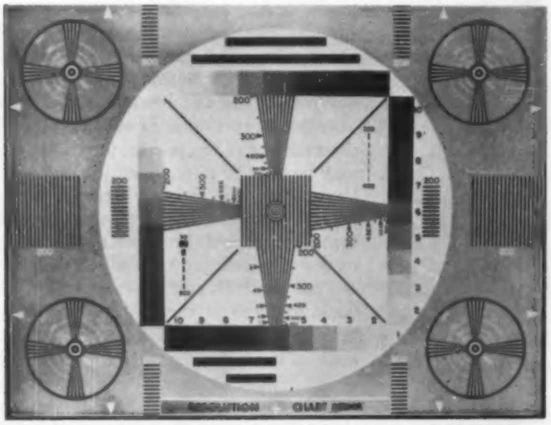

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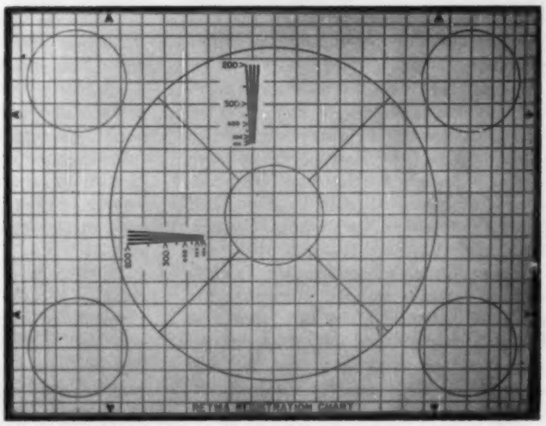

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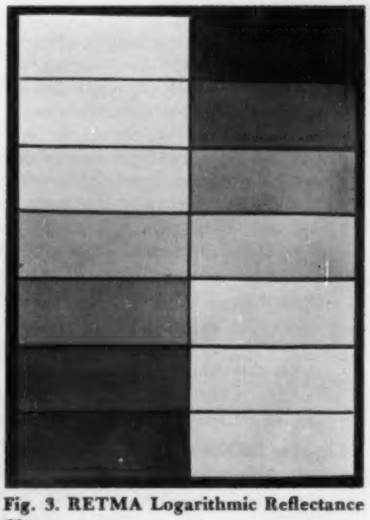

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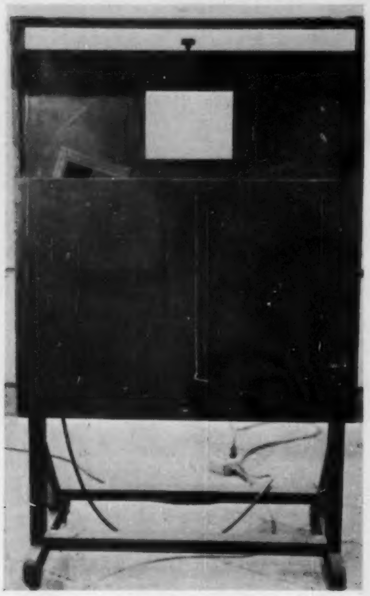

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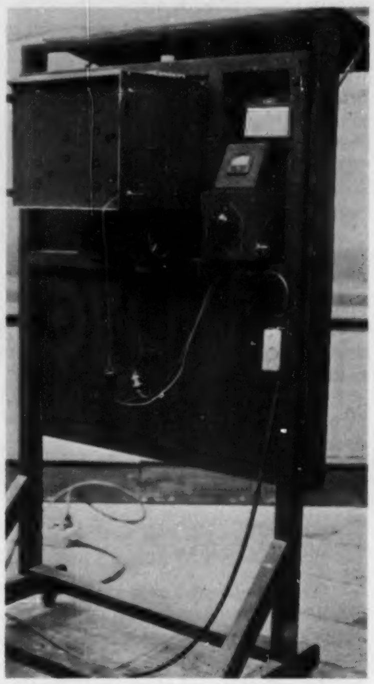

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80TH CONVENTION LOS ANGELES OCTOBER 8—12

An announcement card outlining the main events of the 80th Convention was sent out to members in mid-August. Since then there has inevitably been some shifting of papers, deletions and additions. These can be checked by referring to the Advance Program on the following pages of this issue.

Possibly because of its location in Hollywood, this convention program will put considerable emphasis on motion-picture subjects, with particular attention being paid to recent developments in projection and sound processes and equipment. An area of unusual interest, which has not been featured in any previous convention program, will be a thorough coverage of the principles and applications of transistors as they apply to motion-picture and television equipment uses.

There will be so many outstanding papers and subjects that this may well turn out to be the best attended convention ever. Ralph M. Evans of Eastman Kodak is to give an important paper on sharpness and contrast. An interesting group of papers will deal with a new area in the laboratory processing field — the application of automation principles to lab operations. Those concerned with photographic instrumentation will find high-speed strongly represented, particularly in the field of sled photography, and there will be a full day's trip of unusual interest to the U.S. Navy Electronics Laboratory in San Diego. In the field of television, the event many will be waiting for is the thorough technical discussion of the Ampex Videotape recording process and equipment, which will occupy one entire evening session.

Since the postal announcement went out one hope has had to be canceled: the demonstration of Technicolor's wide-screen process cannot be arranged and has had to be postponed. But the session at M-G-M's new Studio 2, where the M-G-M 65mm system and 6-track stereophonic sound will be demonstrated, should be a special attraction for projection enthusiasts.

In addition to outlining the program, the postal announcement included a hotel rate and reservation card for making room reservations directly with the Ambassador Hotel. If for any reason you did not get one, a few of these cards are still available at Society headquarters — or better, wire the Hotel.

Advance Registration

As in the recent past, an Advance Registration card was also attached to the announcement, enabling members to send in their requirements ahead of time. Members who send their remittances for luncheon and banquet tickets as well as registration with this card to headquarters by October 1 are entitled to a $2.50 discount. Since member registration for the week is $5.00, luncheon tickets are $5.00 and banquet tickets $17.50, this will reduce the price of the package to $25.00. It should be noted, too, that tickets bought for the banquet in lots of ten or more will also be subject to a discount of $2.50 per ticket, and this will apply whether they are purchased beforehand or at the convention. Tables at the banquet will seat ten, and groups may thus be assured of being seated together and at the same time take advantage of the discount.

The speaker at the Get-Together Luncheon will be George Sidney, President of the Screen Directors' Guild, who should have much to tell visitors to Hollywood. In addition to the many delightful events planned for the Ladies Program, such as the trip to Disneyland and the special showing at the Golden Horseshoe Theater mentioned in a previous article (August *Journal*), the Ladies Committee has completed arrangements for a tour of the Warner Bros. studios. The cocktail party and banquet arrangements, which were described in the August *Journal*, have now been firmed up and members and guests are assured of a wonderful evening from the time they gather around the beautiful Ambassador pool until the final dance is danced in the famous Cocoanut Grove.

After the President officially opens the convention on Monday afternoon there will be a short business meeting, open to all members of the Society, at which the results of the elections for the Society's Officers and Governors will be announced. In late August, ballots were circulated to all voting members of the Society to select for two-year terms a President; the Executive, Editorial and Convention Vice-Presidents; a Secretary; and six Governors.

In addition to the technical sessions of the Advance Program, the accompanying roster of Engineering Committe activity will draw heavy attention.

Exhibits

John Olsson reports from Hollywood that space in the Equipment Exhibit to be held at the Ambassador during Convention week is rapidly going. From all indications there will be some highly important displays, including quite a number of new items just in production and now being unveiled to the industry for the first time anywhere. This promises to be the largest and finest show there has been to date and a must for every engineer in the motion-picture and television fields.

A few booths are still available, and those who have delayed until now to take space should get in touch without delay with John B. Olsson, SMPTE Exhibit Chairman, c/o Houston Fearless, 11801 West Olympic Blvd., Los Angeles 64. The following firms have already planned exhibits:

Aerovox Corp. (Pacific Coast Div.)
Andre Debrie Mfg. Corp.
Bell & Howell Co.
Fonda Corp.
Hollywood Film Co.
Houston Fearless
Kling Photo Corp.
Magnasync Mfg. Co. Ltd.
Miller Precision Equip. Inc.
Mole Richardson Co.
Motion Picture Printing Equipment Co.
Neumade Products
Producers Sales Corp.
Radio Corp. of America
S.O.S. Cinema Supply Corp.
Unicorn Engineering
W. M. Welch Mfg. Co.
Westrex Corp.

TENTATIVE SCHEDULE OF COMMITTEE MEETINGS

Monday, October 8
2:00 P.M.—High-Speed Photography
2:00 P.M.—81st Convention Arrangements
4:00 P.M.—82d Convention Arrangements

Tuesday, October 9
10:00 A.M.—Film Projection Practice
2:00 P.M.—Sound

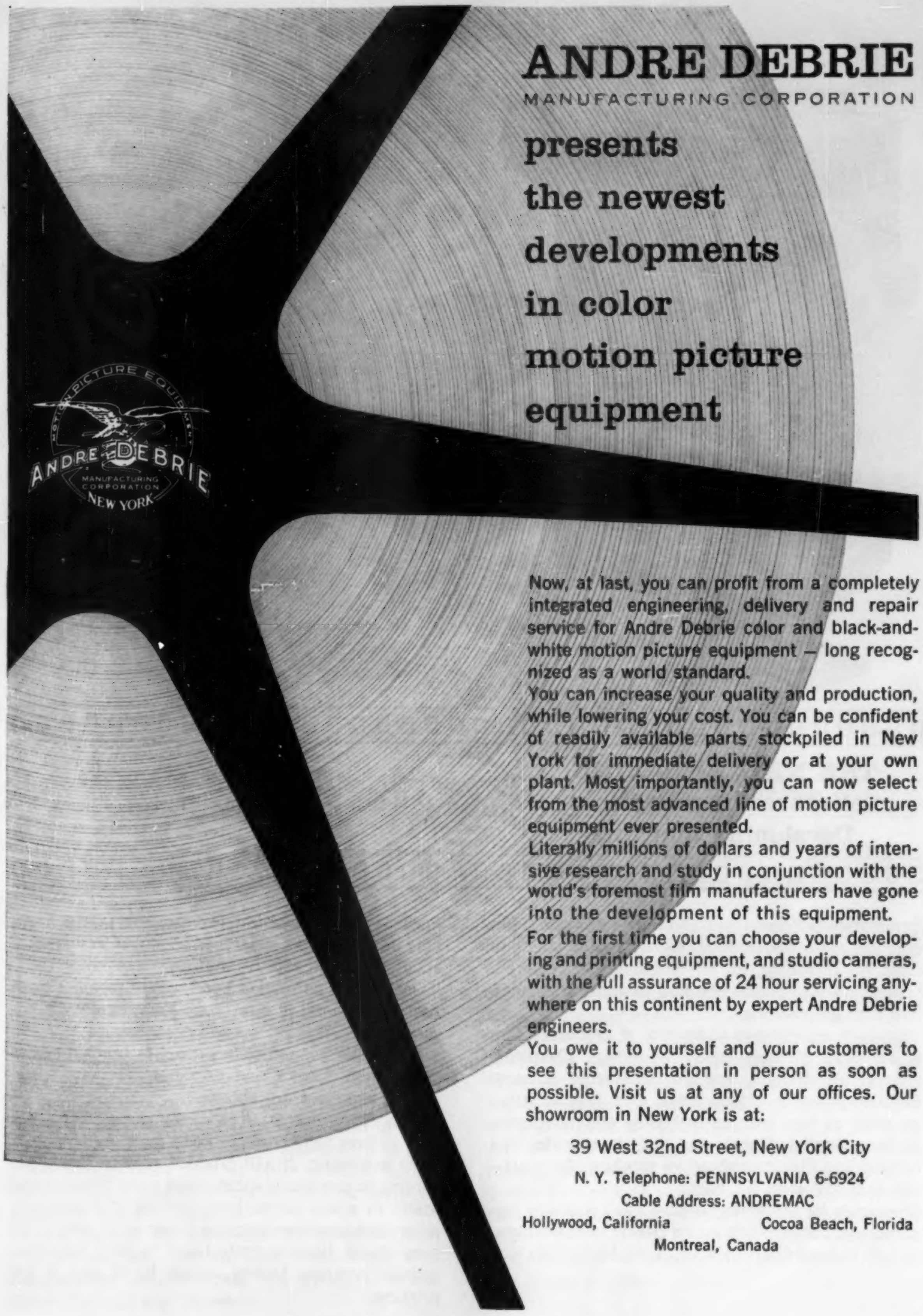
Wednesday, October 10
10:00 A.M.—Laboratory Practice
2:00 P.M.—Screen Brightness
2:00 P.M.—Association of Cinema Laboratories

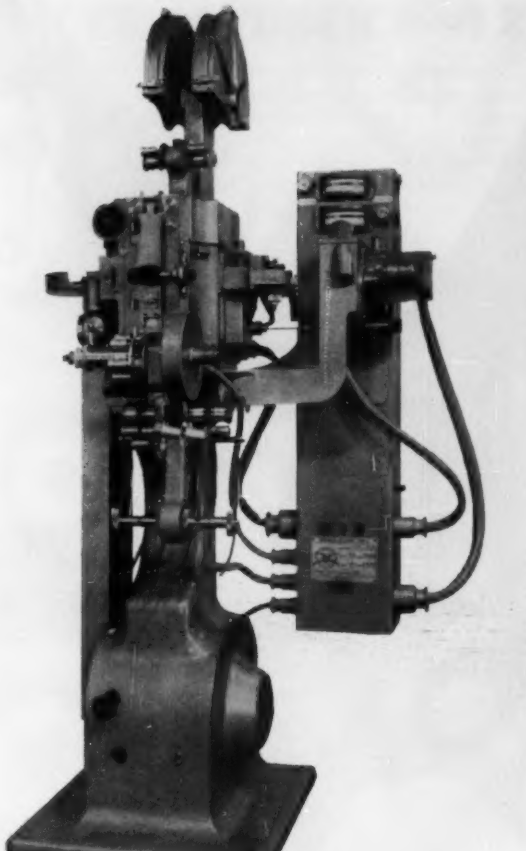
Thursday, October 11
2:00 P.M.—16 & 8mm
2:00 P.M.—Papers Committee/Board of Editors

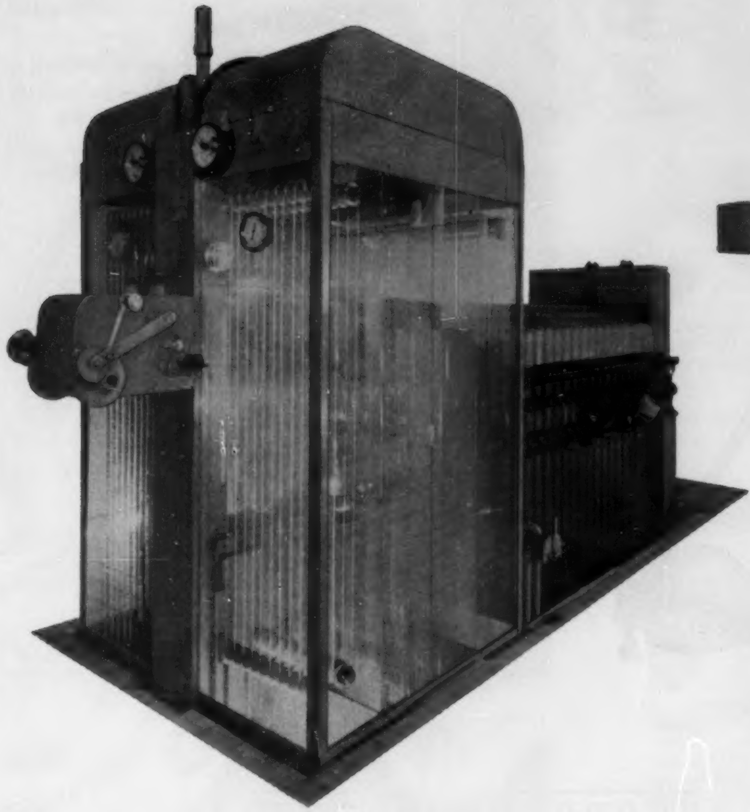
Friday, October 12
10:00 A.M.—Television
2:00 P.M.—Motion Picture Studio Lighting and Process Photography

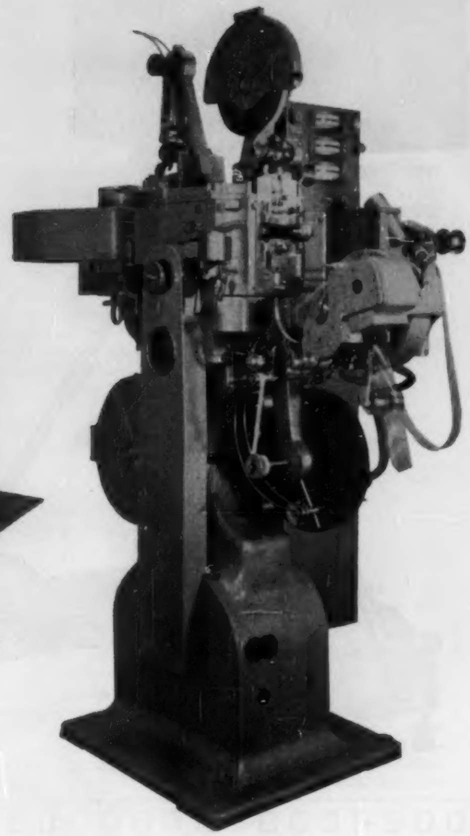
Final schedule of meetings will appear in the Convention Program. Meeting notices will be mailed to all Engineering Committee Members.

Note: High-speed group trip on Thursday (see program) will be limited to 40 persons. Charge per person for round trip chartered air transportation and San Diego bus, $12.00. Those planning to go should notify Roy Wolford, 3434 West 110th. St., Inglewood 2, Calif. by Sept. 28.


MOTION PICTURE EQUIPMENT
ANDRE DEBRIE
MANUFACTURING CORPORATION
NEW YORK







ADVANCE PROGRAM

It is expected that the Convention will come off as outlined below — however, there may be some changes in timing of papers and a very few papers may be deleted or substitutions made.

All practical efforts are made to present a substantial and timely program of papers and demonstrations, even at the risk of some last-minute changes.

If you are interested in a very few specific papers, you should inquire a week before the Convention by telephoning either to Petro Vlahos, Program Chairman, c/o Motion Picture Research Council, 6660 Santa Monica Blvd., Los Angeles 38 (Hollywood 3-3201), or to Society headquarters (LOngacre 5-0172).

SUNDAY—OCTOBER 7

Registration will open at 2:00 P.M. in the Ambassador Hotel.

MONDAY — OCTOBER 8
Convention Registration
Opening Remarks John G. Frayne, SMPTE President

GET-TOGETHER LUNCHEON
GEORGE SIDNEY, President, Screen Dir. Guild

MONDAY AFTERNOON
Motion Picture Practice I

The Analysis of Background Process Screens

ARMIN J. HILL, Motion Picture Research Council, Hollywood

Development of improved translucent screens for process projection has resulted from improved manufacturing techniques which have been accompanied by a systematic study of the characteristics of these screens and improved instrumentation for measuring and controlling these characteristics. This paper discusses the "semidiffuse" transmission of light by translucent screens, using an empirical approach which has been found very useful in the analysis of these screens and which can readily be adapted to reflective screens as well. Applications of this method to the analysis of screen characteristics are considered and a way of rating screen performance against the optimum which might be expected for a given type of screen is indicated.

Distortion of Anamorphosed Images

WALTER WALLIN, Panavision, Inc., Los Angeles

The distortions of an anamorphosed image are algebraically analyzed and classified as nonrectilinearity (pincushion or barrel); nonlinear compression or expansion, and asymmetry. It is shown that some types of distortion are subject to control by the designer, while others depend only on the angular field and the amount of anamorphosis, with any of the known types of anamorphosers. The analysis points to techniques that lead to imagery, that is more nearly distortion-free.

The New Paramount Double-Frame Triple-Head Transparency Background Projector

FARCIOT EDOUART, Paramount Pictures Corp., Hollywood

The new double-frame triple-head transparency background projection equipment has been designed for background composite photography to use the high quality double-frame prints made from VistaVision double-frame negatives. This new precision engineered equipment provides a marked increase in total light output which in turn permits the use of larger transparency screens, or the ability to carry more depth of focus. The improved quality of double-frame prints, together with new, higher quality projection lenses and optical relay elements, produces sharper, clearer transparency background images which further enchances the quality of VistaVision releases. The basic features of this design are discussed in this paper.

An Improved Optical System for Large-Frame Process Projectors

ARMIN J. HILL, Motion Picture Research Council, Hollywood

The Motion Picture Research Council was asked to assist in designing the optical system for a process projector which would deliver approximately four times the light to a process screen as had hitherto been available. The successful solutions of the several interesting problems involved in this design, and several interesting new features which were incorporated in the completed projectors are discussed in this paper.

One More Take!—WHY?

KARL FREUND, Photo Research Corp., Hollywood

MONDAY EVENING
Motion Picture Practice II

Sharpness and Contrast in Projected Pictures

RALPH M. EVANS, Eastman Kodak Co., Rochester, N.Y.

It is found that the apparent overall contrast of a picture, particularly one projected in a darkened room, depends on the contrast of the fine detail in the picture to as great an extent as it does on the large area contrast. The two effects are independent of each other to a considerable extent. A sharper picture appears to have more contrast just as a more contrasty picture appears sharper. The eye adapts to the contrast of a picture and only sudden changes are particularly noticeable. The effects are extensively illustrated and the causes and implications discussed briefly.

TUESDAY MORNING — OCTOBER 9
Laboratory Practice I

The Use of 35/32mm Films for 16mm Black-and-White and Color Prints

WILLIAM E. GEPHART, Jr., General Film Laboratories, Inc., Hollywood

A description of 35/32mm film and the method of its use in producing 16mm prints is given. Slides of the equipment designed and used for handling 35/32mm films are shown and this equipment is described. The advantages of this method of producing 16mm prints are given and demonstrated with a 16mm film.

Combination Printing of 35/32 and 16mm Films

C. J. WILLIAMS and A. L. FORD, Jr., Unicorn Engineering Corp., Hollywood

The problem of printing on 35/32mm films from 16mm negatives and the other combinations of these two film sizes in negative or positive position is discussed. Sprocket, aperture plate, roller, film feed and film take-up modifications are described which permit single printing machines to accomplish any of the above operations.

The Slitting of 35/32mm Films

C. J. WILLIAMS and H. L. BAUMBACH, Unicorn Engineering Corp., Hollywood

The problem of precision slitting of a strand of 35/32mm film into two 16mm films is discussed. The machines which were designed and constructed for this purpose are described in detail. These machines are fully automatic in operation and incorporate gauging devices, micrometer adjustments and safety features. Measurement of the slit films on an optical comparator and quality control procedures are described.

Coating of 32-35 mm Soundtrack on Eastman Color Positive

HENRY GOLDFARB, DeLuxe Laboratories, Los Angeles

New Anscochrome 16mm Reversal

JOHN L. FORREST, Ansco, Binghamton, N.Y.

A Scene Counter for Laboratory Projection Rooms and Some Other Improvements in Laboratory Methods and Control Devices

TED HIRSCH, EDWARD H. REICHARD, CARL W. HAUGE, SIDNEY P. SOLOW, Consolidated Film Industries, Hollywood

Improved laboratory devices, some of which make use of electronic circuits, are described and demonstrated. These include an illuminated scene counter for projection rooms, contact and proximity cueing systems for printing machines, a break alarm for developing machines, a solution level control, punched film programming for printing machines, integrated color and intensity matte for color printing, and self-identifying leaders for television prints.

TUESDAY AFTERNOON
Laboratory Practice II

A New Contact Printer for Direct Dupe Color Negatives

PAUL RAIBAUD, Etablissements Andre Debrie, Paris

This paper describes the new Debrie Matipo contact printer. Factors involved in the successful printing of dupe color negatives, including color correction and registration, color balance, constant color temperature, remote light control and automatic fading, are discussed.

Automatic Printer Operation From Punched Tape and Punched Cards

H. M. LITTLE and H. L. BAUMBACH, Unicorn Engineering Corp., Hollywood

Standard punched tape units have been recoded and modified to bring about automatic operation of film-printing equipment. Punched tape performs the functions of discrete scene-to-scene light changes, dissolve-shutter operation and automatic stopping of equipment, while cards automatically adjust light level and printer characteristics for any particular job.

Complex printer operations may be performed with great accuracy at high speed by the use of these items.

A New Intermediate Positive-Duplicate Negative System

H. J. BELLO, C. E. OSBORNE, and D. M. ZWICK, Eastman Kodak Co., Rochester, N.Y.

A new color film for making duplicate negatives from Eastman Color Negative Film, Type 5248, is described. A color duplicating positive is first made on this material, from which a duplicate negative can be prepared on the same film stock. This film may also be used to make duplicate negatives from black-and-white color separation positives. Sensitometric processing and printing characteristics are described.

Film Processing Machines of Modular Design

W. ENKELMANN, Unicorn Engineering Corp., Hollywood

The familiar building-block system has been applied to motion-picture film-processing machine design. A high degree of flexibility is achieved which enables the modern laboratory to adjust the machine to its needs and to keep pace with film improvements as they appear on the market. The new machine incorporates a dynamically balanced drive, precise film-speed control, and an easily threaded impingement drying unit as part of the modular design.

Applications of a Full-Frame Densitometer and Scanning Densitometer

JOHN FRITZEN, Pathe Laboratories, Inc., Hollywood

A description of a means enabling the close matching of duplicate negatives to original material for use in cut-in effects is given. The instruments, a full frame densitometer and a scanning densitometer are described. An outline of the procedures used is given.

Silicone Waxing for Release Prints

HARRY P. BRUEGGEMANN, Pathe Laboratories, Inc., Hollywood

Paraffin is commonly used as a film lubricant. It is applied to the film in solution, the solvent being either toxic, inflammable or expensive, and has a tendency to cause streaks on the film. A new silicone of the nonfogging variety can be applied to the film in a water suspension just before the film enters the drying cabinet. This system eliminates the disadvantages of paraffin, and also gives better lubrication.

A High-Speed Velvet Cleaner for Color Negative

JOHN W. HARPER, Pathe Laboratories, Inc., Hollywood

This device incorporates four velvet-covered wheels mounted in opposed positions in between which the negative passes. The first pair of wheels is driven at 1400 rpm in a direction opposite to that in which the negative travels. The second pair moves in the same direction as the film, and is not powered. The wheels are enclosed in a chamber that has a vacuum cleaner attached. This cleaning method virtually eliminates subsequent drum cleaning after the initial cleaning.

The Recovery and Re-Use of Developing Solutions Used in the Kodachrome Process

BURTON SMITH and RAYMOND VANDERZANDEN, Sawyer's, Inc., Portland, Ore.

This paper describes the methods used at Sawyer's, Inc. for the recovery and re-use of specific chemicals and the subsequent development of methods enabling complete re-use of all but one solution used in the Kodachrome process. A short discussion of other experiments that explore the potentiality of this field is included.

TUESDAY EVENING
AWARDS

Dr. W. H. Pickering, California Institute of Technology, will speak on "Project Vanguard—The Earth Satellite"

WEDNESDAY MORNING — OCTOBER 10
A CONCURRENT SESSION
Instrumentation and High Speed Photography I

Requirements for Cameras in Guided Missiles

ROBERT M. BETTY, Lockheed Aircraft Corp., Van Nuys, Calif.

This paper discusses the environmental conditions, photographic requirements and accessory and control equipment for cameras used as airborne instrumentation in missiles in the past, present and future. A comparison of developments in performance between vehicles and photographic equipment is made and the missiles systems' requirements of industry described.

High-Speed Photography at the Air Force Flight Test Center

WILLIS E. HARRISON, U.S. Air Force, Edwards Air Force Base, Calif.

After brief introductory remarks, this presentation will consist entirely of a 16mm narrated color motion picture showing activities such as high-speed track testing, aircraft testing and rocket engine testing. Some spectacular test shots of sleds going through the barrier and actual sound effects of the sonic boom, etc., will be included.

Photographic Instrumentation—Project SMART

DARRELL LASSITER and WILLIAM KRUPP, Coleman Engineering Co., Hurricane, Utah

Project SMART, Supersonic Military Air Research Track, is a 12,000-ft supersonic sled track designed and built for the Air Force by Coleman Engineering Co. Inc., Los Angeles, Calif. The track is located and operated to simulate pilot escape systems of high-speed aircraft. Photographic instrumentation of this site is described.

Portable Power Supply for High-Speed Cameras

DONALD H. PETERSON and NEIL G. CURRIE, North American Aviation, Los Angeles

This paper describes use of "systems" approach in the design of a portable power and control unit for high-speed motion picture cameras. The unit is complete with controls, timing device and remote panel from which the cameraman controls lighting, cameras, test event and other instrumentation. Ability to move quickly to test site, obtain all power from a single connection to plant supply and establish a reliable, accurate program control increases the usefulness of the high-speed camera as an engineering tool in aviation development.

WEDNESDAY MORNING — OCTOBER 10
A CONCURRENT SESSION
Projection & Viewing

A Cold-Focus Gate

VICTOR MERRILL, Tarc Electronics, Inc., Westbury, N.Y.

At higher values of radiant-energy flux, the effects of heat-on-film appear, such as in-and-out of focus, brittleness, embossing and distortion, on film used to project motion pictures, when still picture projection is attempted melting and/or complete combustion of the film results. The Cahill-Merrill Cold Focus Gate removes all effects of heat-on-film. Every frame is in perfect focus and undamaged during the entire projection cycle, which may be $^1/_{48}$ of a second or of many hours' duration.

The Adjustable Motion-Picture Screen Frame

HAL GOLDSTEIN and DEAN GRIFFIN, G & G Specialties, Los Angeles, Calif.

The movement to change screen sizes and ratios began a few years ago and the exhibitor was immediately involved. Greatly varying screen frames were installed all over the world. Some were as big as they could be and flat; others, as big as they could go curved; then came the installation of deep-curved frames. To meet exhibitors' demands in for varying projection possibilities, the adjustable screen frame was developed.

Heat-Reflecting Filters—Their Properties and Use in Carbon-Arc Projection Systems

RUDOLPH FISHER and MARTIN PLOKE, Zeiss Ikon, Kiel, Germany

The High-Pressure Xenon Lamp for Motion-Picture Theater Projection

HEINZ ULFFERS, Zeiss Ikon, Kiel, Germany

Improved High Intensity Rotating Positive Carbons for Motion-Picture Projection

R. B. DULL, J. G. KEMP, Jr., and E. A. NEEL, Jr., National Carbon Co., Fostoria, Ohio

Improved 10mm and 11mm High Intensity Projector carbons have been developed for rotating positive carbon type motion-picture projection lamps. These carbons, designed for 95—110 and 110—129 amp respectively, give substantial increases in light and efficiency, and operate more steadily and with greater stability than former carbons of the same size and type. Performance data are presented.

Minimizing the Effects of Ambient Light on Image Reproduction

G. L. BEERS, Radio Corp. of America, Camden, N. J.

One of the important factors in determining the quality of either a television or motion-picture image is the ambient light to which the image is subjected and the effect of this light on the reproduced picture. Some of the means which have been employed to minimize the effects of ambient light on picture reproduction are discussed. A method has been developed which under favorable conditions has produced startling results in permitting the reproduction of both television and motion-picture images under adverse ambient-light conditions. The paper describes this method and gives experimental data illustrating its effectiveness under typical conditions. Some of its limitations are indicated. A demonstration will be given showing the application of the method to the reproduction of motion pictures.

Effect of Gate and Shutter Characteristics on Screen-Image Quality

WILLY BORBERG, General Precision Laboratory Inc., Pleasantville, N. Y.

Comparative measurements demonstrating the film behavior in curved and straight projector gates are given. The analysis takes account of operation under high light levels with two- and three-bladed shutters.

WEDNESDAY AFTERNOON
A CONCURRENT SESSION
Instrumentation and High Speed Photography II

Photography of the Deep Sea Floor

CARL SHIPEK, U.S. Navy Electronics Laboratory, San Diego

A High-Intensity Electronic Light Source for High-Speed Cameras

WILLIAM C. GRIFFIN, U.S. Naval Ordnance Test Station, China Lake, Calif.

Illumination for high speed photography has been provided by various methods including the Argon flash, photoflash lamps, flash powder, carbon arcs, incandescent sources and electronic flash. The electronic flash as used by Hinz, Main and Muhl, has advantages over other methods. However, the shape of the light pulse is far from uniform. A method of shaping the pulse of light is described.

High Frame-Rate Argon Flash for Field Photography

R. C. SEWELL, U.S. Naval Ordnance Test Station, China Lake, Calif.

The Third International Congress on High-Speed Photography

RICHARD O. PAINTER, General Motors Proving Ground, Detroit, Mich.

The Third International Congress on High-Speed Photography—A Report

CARLOS H. ELMER, U. S. Naval Ordnance Test Station China Lake, Calif.

The Third International Congress on High-Speed Photography will be held under sponsorship of the British Department of Scientific and Industrial Research in London from September 10 to September 15, 1956. The author will describe the proceedings of the Congress, and will briefly review the papers presented. The author will bring to the SMPTE meeting copies of all papers presented at the Congress, and will discuss these papers with interested persons following adjournment of the session.

WEDNESDAY AFTERNOON
A CONCURRENT SESSION
Sound Recording

Recent Developments in Multichannel Stereophonic Recording Systems

E. W. TEMPLIN, Westrex Corp., Hollywood

The development of new facilities for deluxe large-scale motion-picture presentations has stimulated a commensurate advance in the realism of the reproduced sound. The paper discusses the significant advances in equipment performance and operating technique found desirable in the six- and seven-channel stereophonic systems associated with these presentations, and describes the recording, re-recording and electrical printing facilities developed for such usage in several of the major Hollywood studios.

Replaceable Pole Tip Caps for Cinemascope Magnetic Reproduce Heads

MICHAEL RETTINGER, Radio Corp. of America, Hollywood

Ring-type magnetic recording and reproducing heads are contacted by the abrasive medium, and hence their useful life is shortened by a wear process. The subject replaceable pole tip cap consists of a pair of brass holders in which the

laminated tips of the cores are plasticized. The cap is fastened to the main housing assembly by means of two 1-72 screws, and locating pins are employed to assure correct azimuth on the part of the precision-aligned pole cap.

When the cores of a cap are worn, the cap is removed by unfastening the two mounting screws and detaching the cap, after which a new cap may be substituted. For reproduce heads, the tips as well as the cores are made of laminated Permalloy. For recording heads, in order to lower bias current requirements, the tips are made of laminated Permalloy and the cores of solid ferrite.

Improved Magnetic Recording and Re-Recording Facilities

G. R. CRANE, Westrex Corp., Hollywood

Recent advances in studio use of multichannel magnetic recording and reproducing have required the development of specially designed film transport mechanisms. This paper describes a basic design with sufficient versatility to meet all the varied requirements imposed by film widths ranging from 16mm to 70mm, and by a wide range of film speeds. A choice of magnetic heads and transmission facilities provides for single or multitrack operation with up to 7 channels. Versions for optical or magnetic operation and magnetic printing are also included.

Bulk Magnetic Film Demagnetising Practices

KENNETH B. LAMBERT, M-G-M Studios, Culver City, Calif.

This paper will be a very brief summary of practices used in the several Hollywood studios. Significant factors which have been observed, and problems which are encountered, will be mentioned.

WEDNESDAY EVENING

Cocktail Party and Aquacade
Banquet and Hawaiian Entertainment

THURSDAY MORNING — OCTOBER 11

Instrumentation and High-Speed Photography full-day field trip to U.S. Navy Electronics Laboratory, San Diego

TELEVISION I

A New Animation Stand

JOSEPH A. TANNEY and ALAN C. MACAULEY, S.O.S. Cinema Supply Corp., New York

This paper describes the Tel-Animastand, a small animation stand embodying all the basic movements required in such equipment and capable of achieving optical effects such as pans, angles, zooms or quick closeups. A sliding cell board with Acme pegs, a 360° calibrated compound table and an east/west/north/south movement and zoom mechanism are also discussed.

A Compact Hot Press Title Machine

JOSEPH A. TANNEY and ALAN C. MACAULEY, S.O.S. Cinema Supply Corp., New York

The Tel-Animaprint, a compact hot press which heats its own type, prints dry in any color, horizontally, vertically or at any angle is described. The equipment is accompanied by an Acme peg bar lineboard for imprinting acetate cells, paper or cardboard. Uses are given for titles, superimpositions, three-dimensional drop shadow effects, advertising copy and TV commercials.

Automatic Television Film Editing

ROBERT GRUNWALD and RICHARD WALLACE, The Harwald Co., Evanston, Ill.

The requirements for film editing and inspection in a television-station film operation are quite different from those encountered in any other branch of the motion-picture industry. Inspection must be very accurate and ranges from mechanical inspection of high accuracy to checking lip sync. Heretofore,

there has been no complete equipment which was designed to perform all of these necessary operations simultaneously. The INSPECT-O-FILM Editor has been developed to meet this need. Operating details of this machine are discussed with particular emphasis on how it may be used in actual operation.

An Automatic Rewinding and Cleaning Machine for Motion-Picture Films

A. L. FORD, Jr., Unicorn Engineering Corp., Hollywood

This paper describes an automatic machine in which motion-picture film rolls are rewound and cleaned in one operation at 360 ft/min. A new type of combination air and vacuum squeegee permits cleaning of 3000-ft rolls at this speed. Use of the machine in production permits successive printing of negatives without other periodic wet cleaning techniques.

Covering the News in Color

ARTHUR E. HOLCH, NBC News, New York

THURSDAY AFTERNOON
TELEVISION II

Production Standards for TV Film Commercials

EDWARD W. BALLENTINE, Acme Film Laboratories, Hollywood

A discussion of the need for better coordination and production planning of television film commercials from the standpoint of the film-processing laboratory. Such planning can eliminate a major portion of these problems by the correct use of (a) various types of raw stock used in the picture; (b) recording voice track, lip sync track and music at proper levels in terms of gamma for laboratory handling, viz., whether music source is original, dupe of a track, transcription from a disc, re-recording from a tape, or a blend of all of these at miscellaneous speeds; (d) optical effects and titles; (e) coordination of these essentials for good editing. This planning is vital in order for the laboratory to deliver prints of the highest standards to networks and stations for good TV transmission.

A 2 x 2 Slide Projector for Color Television Film Systems

R. D. HOUCK and A. E. JACKSON, Radio Corp. of America, Camden, N. J.

Color television film system requirements for a slide projector are more rigid than those of a monochrome television film system. The slide projector described in this paper was designed to fulfill the color requirements. In addition this projector includes operational features which exceed the essential broadcast needs as defined by a survey of representative television stations.

Slide capacity is more than doubled over that of projectors currently in wide usage. Easily loaded drum type slide holders are used in conjunction with dual slide channels. Internal optical multiplexing permits continuous slide programming. Color balance problems between slide channels are eliminated by the unique optical and multiplex systems. Evenness of slide illumination exceeds that of currently available projectors and light output meets all requirements for vidicon film camera systems. The unit is designed to work with currently available equipment as well as to replace units in older monochrome or color film system installations.

Camera Tubes Used in Color-Television Broadcast Service

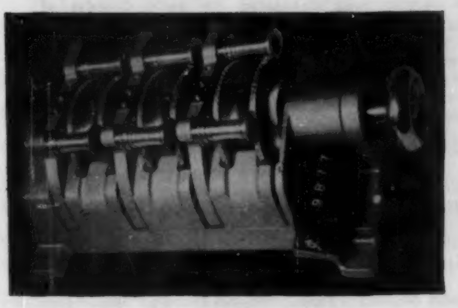
R. G. NEUHAUSER, Radio Corp. of America, Lancaster, Pa.

A brief review is made of tubes currently used in television camera systems and of tubes which have been found basically unsuitable for color camera work. General requirements of tubes for color-television pickup are discussed, and basic performance characteristics that limit the pickup field to several tubes for color television are evaluated. The performance characteristics of vidicons and image orthicons now used are compared with the required characteristics. Quality problems encountered in color pickup are discussed, and methods used to overcome these problems are described. Operating devices used to improve performance are evaluated.

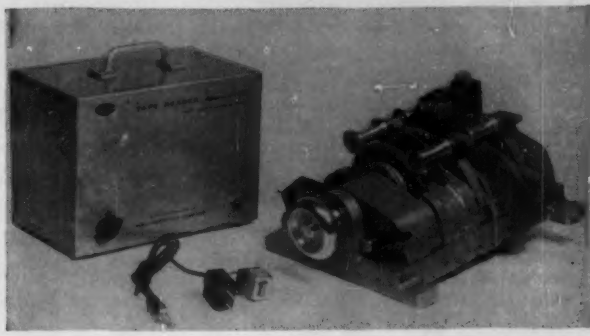
Color TV Program Recording Employing Lenticular Film

R. D. KELL, JOHN BRUMBAUGH, RCA Camden, and E. D. GOODALE, NBC New York

SYNCHRONIZER HEAVEN



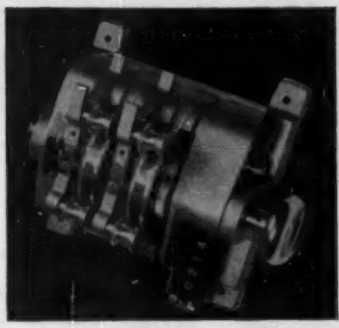
35mm 3-Way Synchronizer $165.00



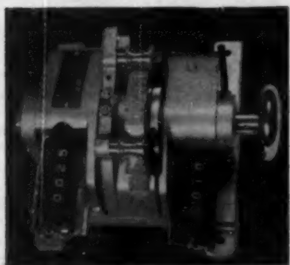
1. Fastens to roller arm of synchronizer.
2. Sync dailies quickly without using editing machine.
3. Ideal for checking sound track for words or effects to be replaced.
4. Fastest and most accurate in locating beginning and ending of words.
5. Tape head can be slid up and back to read a track in any position of fullcoat or magnastripe.

Selling Price:

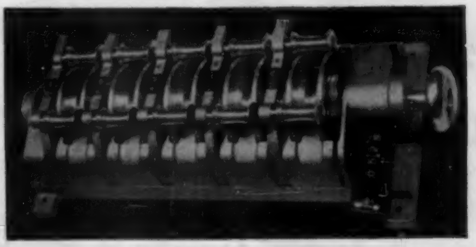
HFC Magnetic Tape Reader Synchronizer attachment	$34.50
HFC Magnetic Tape Reader Amplifier	55.00
Complete Unit	89.50



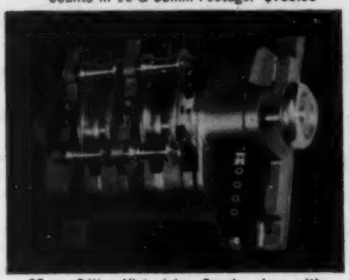
16mm 2-Way Synchronizer $125.00



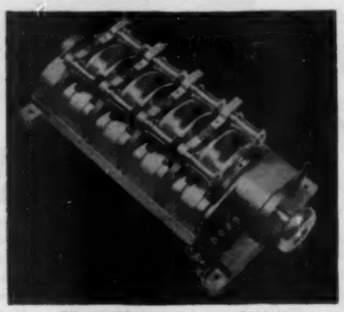
16mm Special Measuring Machine. Counts in 16 & 35mm Footage. $160.00



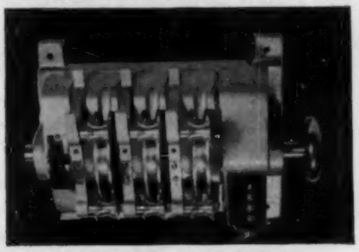
35mm 5-Way Synchronizer $225.00



35mm 2-Way Vistavision Synchronizer with Footage & Frame Counter $160.00



35mm 4-Way Synchronizer $190.00



16mm 3-Way Synchronizer $165.00

65-35mm Combination Synchronizer $380.00

AT BETTER DEALERS EVERYWHERE

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precision film editing equipment

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HOllywood 2-3284

Densitometry of Eastman Embossed Kinescope Recording Film

W. R. J. BROWN, C. S. COMBS, and R. B. SMITH, Eastman Kodak Co., Rochester, N.Y.

The requirements for image analysis of Eastman Embossed Kinescope Recording Film, Type 5209, are discussed. The actual distribution of density of the embossed film image is shown. The optical requirements necessary to analyze these images are similar to those used in projection. It is further shown that these requirements can be made by a comparatively simple modification of an ERPI Densitometer. The results of sensitometric evaluation of satisfactory color images measured on this modified instrument are shown.

THURSDAY EVENING TELEVISION III

The Ampex Videotape Recording System—A Symposium of 3 Papers

CHARLES P. GINSBURG, CHARLES E. ANDERSON and RAY M. DOLBY

FRIDAY MORNING — OCTOBER 12 TRANSISTORS I

The Transistor

R. D. MIDDLEBROOK, California Inst. of Technology, Pasadena, Calif.

A general qualitative introduction to the semiconductor diode and transistor is presented. The wartime development of the point contact rectifier led to the discovery of the point contact transistor, which was followed by the invention of the junction diode and transistor having many superior properties. The basic physical principles of operation and various commercial devices are discussed. High frequency effects, and modified forms of the original transistor which improve the high frequency performance, are described. Several methods of transistor manufacture are described. Demonstrations and many slides illustrate the talk.

The Role of Transistors in Electronics

RICHARD B. HURLEY, Convair Div., General Dynamics Corp., Pomona, Calif.

While the vacuum tube dominated the early decades of electronics, events centering around the turn of this century indicate a swing to solid state electronics. In particular, the junction transistor (and diode) with support from the saturable magnetic core appears capable of a strong invasion of almost all branches of electronics.

Although transistors suffer a disadvantage (compared to tubes) in temperative sensitivity, their advantages include ruggedness, long life, lack of heater supply, and high circuit efficiency. They can operate on an analogous basis to tubes, a dual basis and in yet different modes. As a switch, they are superior to tubes and offer many advantages over electromechanical relays. In conjunction with saturable cores they can compete successfully with certain rotating machines as well as offering a large class of almost unexplored electronic circuits.

Magnetic amplifiers have been increasing in importance steadily, dielectric amplifiers have entered the electronics picture, but the transistor and other semiconductor devices are making the revolutionary strides. Considering the advantages and the various modes of operation of junction transistors, the two carrier polarities possible, the myriad of other present and future types of transistors, and support from new "VR" and rectifying diodes and saturable cores, the transistor should soon be the principal active circuit element. It appears that the transistor will play the leading role in communications, control and computation as well as in measurement and power-supply-circuits.

FRIDAY AFTERNOON TRANSISTORS II

Applications of the Transistor to Motion Pictures and Television

H. J. WOLL, Radio Corp. of America, Camden, N.J.

Transistor Amplifiers for Mixing Magnetic Recording and Reproduction

WILLIAM V. STANCIL, Stancil-Hoffman Corp., Hollywood

Taking advantage of the compactness and efficiency of transistors, a complete recording channel has been developed which offers the same performance as vacuum-tube circuitry. While the signal-to-noise may be 3 db above tubes operated under ideal laboratory conditions, the transistors, in practice, perform better since there is no hum and microphonics.

The equipment to be demonstrated will include microphone preamplifiers, bridging, recording and playback amplifiers and a 60-kc bias oscillator. All units are on printed cards of plug-in design.

A Transistorized Seven-Position Portable Mixer

KURT SINGER, Radio Corp. of America, Hollywood, Calif.

This paper deals with the description of a seven-position portable mixer, which has been transistorized throughout. Its electrical facilities and mechanical construction are described fully. A detailed circuit description of the individual transistorized amplifiers, together with explanation of constructional features, is also given. Excellent stability, low distortion and a very good signal-to-noise ratio have been obtained in this equipment.

FRIDAY EVENING
Demonstration of M-G-M 65mm system and 6-channel stereophonic sound at Stage 2, M-G-M Studios

Board of Governors

On Friday, August 3, the Board of Governors held its third meeting of 1956 at the Hotel Biltmore in New York City. As is customary at the midyear meeting the Board reviewed Budget II, a proposed revision of the 1956 budget, designed to adjust the earlier figures to the level of operations estimated for the remainder of the calendar year.

The Board approved publication of the booklet "Elements of Color in Professional Motion Pictures," a project of the Society's Color Committee. As reported in the August *Journal*, this booklet is expected to be available by early December.

Publication of a 5-Year Journal Index, 1951–55, was approved, and this project is now underway.

The film dimension Standards, PH22.34 (Dimensions for 35mm Motion-Picture Negative Raw Stock) and PH22.102 (Dimensions for 35mm Motion-Picture Film, Alternate Standard for Positive Raw Stock) were presented to the Board and approved for submittal to the Photographic Standards Board of the American Standards Association.

Section Activities

Ethan M. Stifle, Sections Vice-President, presented a set of Administrative Practices governing the operation of Sections and Student Chapters which had been circulated to the Board prior to the meeting. The Board recommended that all Sections be named after their headquarters cities due to the difficulty of naming them after the areas they cover. The Section territories were broken down as follows:

New York Section: Massachusetts, Rhode Island, Connecticut, Pennsylvania, New Jersey and Southeastern New York, below a line drawn between Binghamton and Albany, but not including these two cities.

Chicago Section: North and South Dakota, Nebraska, Kansas, Minnesota, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, Ohio and Kentucky.

Los Angeles Section: New Mexico, Arizona, Southern California and Southern Nevada — the dividing line to be the extension of the southern boundary of Utah through Nevada and California.

San Francisco Section: Montana, Washington, Oregon, Idaho, Wyoming, Colorado, Utah, Northern Nevada and Northern California.

Rochester Section: Maine, New Hampshire, Vermont and Northeastern New York above a line drawn through Binghamton and Albany, and including these two cities.

Atlanta Section: North and South Carolina, Tennessee, Alabama, Florida, Mississippi and Georgia.

Dallas — Ft. Worth Section: Oklahoma, Arkansas, Louisiana and Texas.

Washington, D.C., Section: Delaware, Maryland, West Virginia, Virginia and the District of Columbia.

The Board accepted these Administrative Practices as an interim measure pending further study. They will be reviewed again at the Fall Board meeting.

The Washington, D.C., Section came into existence in April 1956. At the Spring meeting in New York on April 29, the Board approved a petition signed by 48 members in the Washington area for establishment of the Section. An organizational meeting was held on June 25, and a slate of officers was nominated for the coming year. The group will hold their first technical meeting in Washington on October 22.

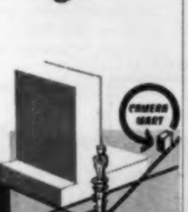
Because of the increase in the number of Sections, Wilton R. Holm, Secretary, and Barton Kreuzer, Executive Vice-President, suggested that a review be made of the Constitution and Bylaws with a view to:

1. Assuring equitable and representative selection of Officers and Governors;
2. Considering revision of Section 5, Bylaw V, relative to admissions committees;
3. Considering the extent of representation of Sections on the Board of Governors.

With the Board's approval Dr. Frayne stated he would appoint a committee to make such a study.

Reports submitted by John W. DuVall, National Membership Chairman, and Reid H. Ray, Sustaining Membership Chairman, indicated substantial increase in both types of membership in 1956. Mr. Ray also reported that 27% of 86 Sustaining Members that were contacted increased their contributions for this year.

Dr. Frayne, Chairman of the Education Committee, reported that the University of Southern California will continue the sound course initiated by the Society during the Spring semester of 1956; and that



UCLA will conduct laboratory technician training courses.

He stated that approximately fifty letters have been sent to people concerned with the field of motion-picture projection asking for their thoughts on a Society-sponsored projectionist training program. All those replying indicated a favorable reaction to the project. Plans were made to initiate and to investigate ways and means of establishing and conducting such a training program.

The Board accepted the names of candidates for Society awards for 1956 submitted by the Fellow, Journal, Warner, Kalmus, Sarnoff, Honorary Membership and Progress Medal Award Committees. Medals and certificates will be presented to award recipients on October 9 during the 80th convention in Los Angeles.

The slate of candidates for national Society office for the two-year term January 1957 through December 1958 was also accepted by the Board which directed that preparation and circulation of election ballots to voting members proceed at once.

Dr. Frayne presented, and the Board approved, a recommendation made by Axel G. Jensen, Engineering Vice-President proposing establishment of a joint IRE-RETMA-SMPTE committee to study magnetic video tape recording techniques. This committee would follow developments in this field and make periodic progress reports. It would serve as "a clearing house for information and would be able to give competent advice to the industry regarding this new development."—*S.G.*

current literature

The Editors present for convenient reference a list of articles dealing with subjects cognate to motion-picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D.C., or from the New York Public Library, New York, N.Y., at prevailing rates.

American Cinematographer vol. 37, June, 1956

Movies on Tape (p. 352) *F. Foster*

Bob Bailey's Homemade 16mm Film Processor (p. 356) *B. Gray*

Importance of Viewing Glass in Cinematography (p. 362) *L. Allen*

Audio vol. 40, June, 1956

Compression and Dialog Equalization in Motion Picture Sound Recording (p. 17) *E. P. Ancona, Jr.*

Bell Laboratories Record vol. 34, July, 1956

Color Television on the L1 Coaxial Carrier System (p. 255) *H. C. Hey*

International Projectionist vol. 31, June, 1956

A Common Sense Approach to Screens, Apertures and Aspect Ratios. I. (p. 7) *R. A. Mitchell*

Kino-Technik vol. 6, June, 1956

Praxis und Geräte der Filmaufnahmen unter Wasser (p. 223) *D. Rebikoff*

Die Bausteintechnik der Telefunken-Tonfilmanlage (p. 226) *H. Friedrich* and *W. Straub*

Aus der Geschichte der Kinematographie, V. (p. 230)

Radio & Television News vol. 56, July, 1956

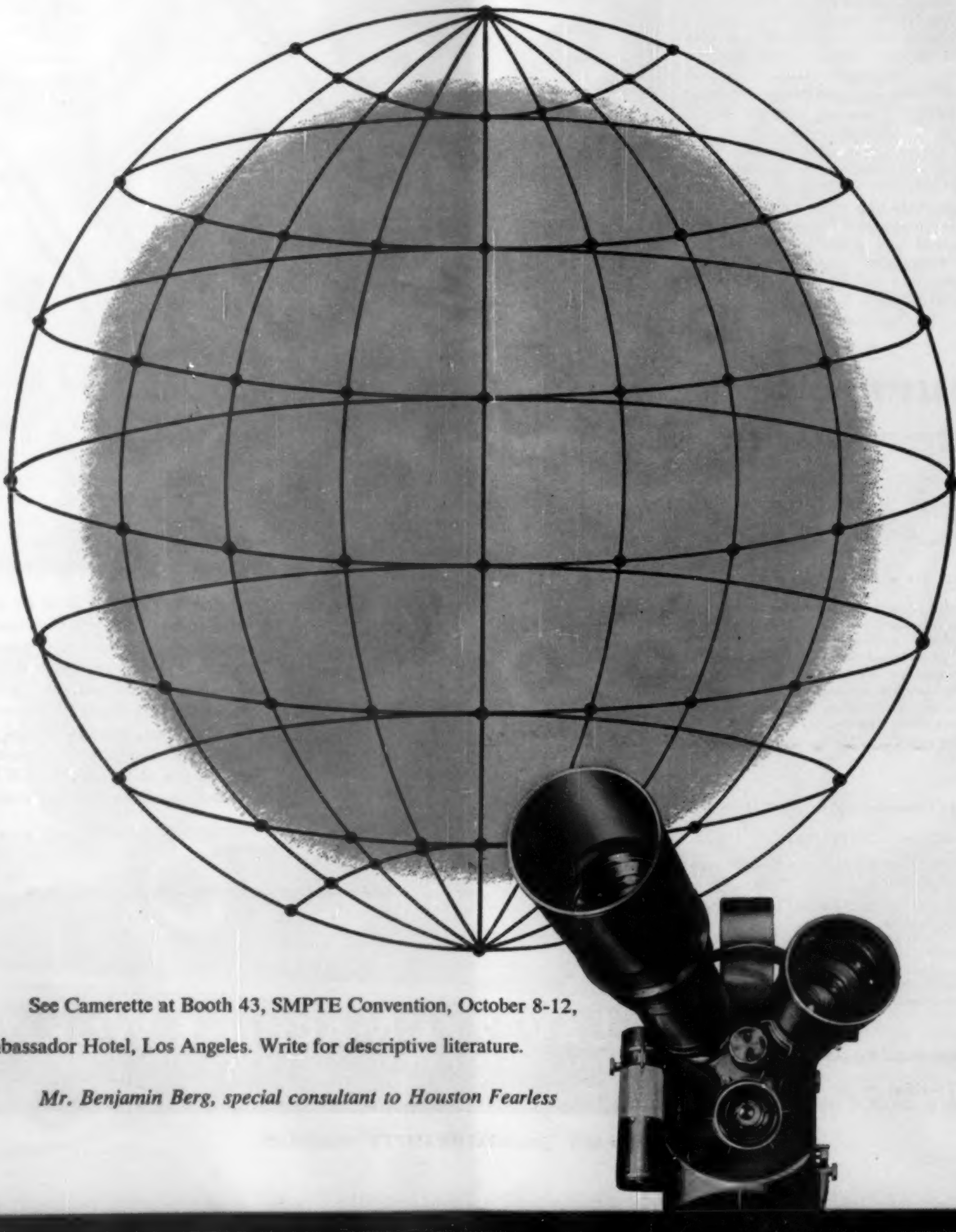
A New Single-Gun Tube (p. 62)

Science and Film vol. 5, June, 1956

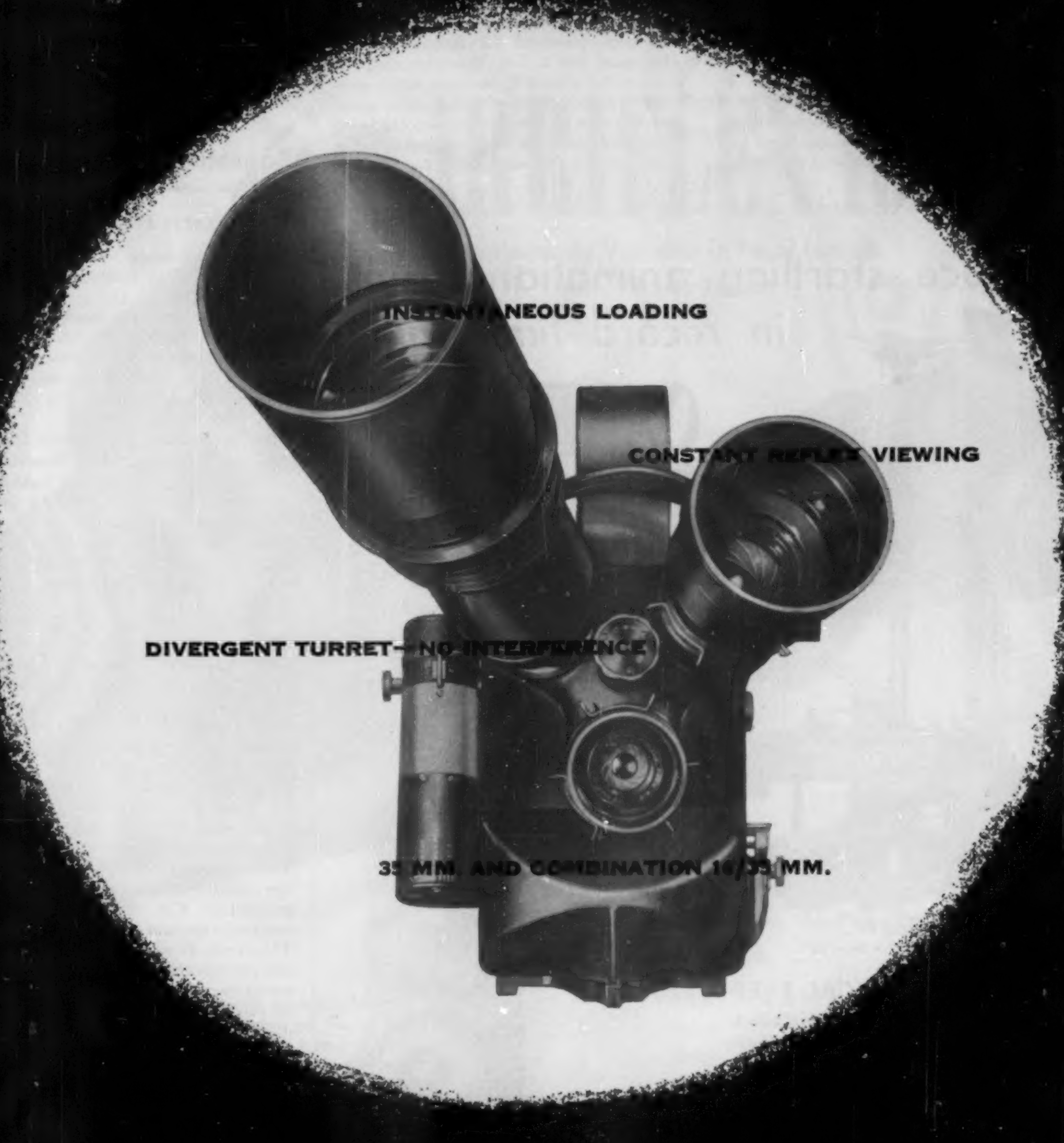
A New 35mm Stereo Film Camera (p. 11) *R. Spottiswoode*

engineering activities

Presented in last month's *Journal* was a report of eight of the nine engineering committee meetings held during the Society's 79th Convention in New York City, April



CAMERETTE



Houston Fearless is appointed by Eclair, new exclusive distributor for Camerette,

the versatile motion picture camera preferred by the world's leading cinematographers. Houston Fearless pledges the same prompt, efficient service you have come to expect of the world's leading manufacturer of television and studio motion picture equipment and film processors.

HOUSTON FEARLESS Division of Color Corporation of America
11809 West Olympic Boulevard, Los Angeles 46, California

29 – May 4, 1956. The report of the High-Speed Photography Committee meeting was not included and is being presented at this time.

The committee previously had given consideration to the problems associated with the procurement of camera lenses resulting from the variety of lens mounts and differing distances between the lens mount surfaces and film plane. A subcommittee had been appointed with M. E. Brown as chairman, to study this question in detail and come up with a recommendation. At this meeting, the subcommittee submitted its recommendation which, after review, was approved for letter ballot and consideration of the entire committee. In brief, this recommendation specifies that high-speed motion-picture cameras shall have a machined plane surface for mounting lens adapters and that the manufacturer shall supply with each camera sufficient data for locating the mechanical and optical distance from this surface to the plane of the film.

At the December 1955 committee meeting, a new 16mm 200-ft camera spool, had been proposed for standardization. This spool has a 1-in. diameter core, in place of the present 1¼-in. core, which provides a certain degree of miniaturization. The question of whether to proceed with standardization was not resolved at that time and the discussion was continued at this meeting. Several arguments were presented against having two differing spools in existence and while the discussion was not conclusive, it appears unlikely that such standardization will be initiated for the time being.

There was also discussion on the Third International Symposium on High Speed Photography to be held in London this year, the progress being made in the nomenclature project and plans for papers for the Society's 80th Convention.—*Henry Kogel*, Staff Engineer.

Education, Industry News

Thirty Years Hence

"In sound recording . . . electronic methods have made much headway against photographic recording . . ."

This statement was made November 1, 1955, in the Presidential Address of Dr. H. Baines before the Royal Photographic Society of Great Britain on the subject of "Thirty Years Hence" (*The Photographic Journal* for February 1956).

In his introductory remarks, Dr. Baines explained that rather than "flounder on the foreshore of the future," he would "swim out strongly and drown in the uncharted seas of thirty years hence . . . ."

A portion of his address in which he comments on the actualities and potentialities of TV recording on magnetic tape is quoted:

"About 70 per cent of professional 35mm films have their sound recorded on magnetic tape, and although the records are usually dubbed on to normal sound film, this is only a matter of expedience at the present time. Magnetic tape has also been applied to the recording of views, and it may be of interest to compare the process with photographic recording In the system adopted by the B.B.C., a TV camera scans a view by tracing 202½ horizontal lines in 1/50th second, and then re-scans along intermediate lines. The total cycle, therefore, takes 1/25th second to scan 405 lines per picture. This view can be recorded on magnetic tape and projected therefrom on a TV screen. It might be argued that this is not photography, but an image on a TV screen from a magnetic tape which cannot be directly visually examined, has something in common with an image on a table viewer from a miniature still or substandard cine film, which cannot conveniently be directly visually examined, and no one would deny that the latter is photography.

"The TV system has the advantage over photography that a high-sensitivity TV camera is at present about twice as sensitive as the fastest photographic material exposed 1/25th second at the same aperture, and, since television is in its infancy, one can expect this ratio to increase. . . .

"At present, TV is no rival to photography for normal photographic purposes, but as soon as the advantages become real, expense will be no bar to its application, in commercial photography at any rate. Prospective users always start by deciding that they cannot afford an innovation, and rapidly realize that they cannot afford to neglect it!"

John A. Maurer has organized a new firm called JM Developments, Inc., located at 116–118 West 29th St., New York 1, N.Y. Mr. Maurer was formerly President of J. A. Maurer, Inc., and Precision Film Laboratories, and later engaged in independent research and development.

Election of Carl L. Bausch as Chairman of the Board and Dr. Howard S. Coleman as Vice-President in Charge of Research and Engineering has been announced by the Bausch & Lomb Optical Co., Rochester, N.Y. Before his present appointment Mr. Bausch held the post of Senior Vice-President. He joined the firm in 1909, was named a director in 1931, and became Vice-President in Charge of Research and Engineering in 1935. He succeeds the late Joseph F. Taylor.

Dr. Coleman, 39, is one of the youngest men in the country to head research and engineering activities for a major firm. He joined Bausch & Lomb in 1951 as director of its Scientific Bureau.

The Library of Congress is requesting film distributers and producers to cooperate with the Library's film cataloging activities by supplying it with information on films available for public distribution. Forms for the necessary data are available from the Library of Congress, Washington 25, D.C.

In the usual order: Kiyohiko Shimasaki, Managing Director of the Japanese Society and Editor of its monthly *Journal*, Robert A. Haines, holding the Award Certificate, and Mrs. Haines, holding the plaque.

Robert A. Haines, Executive Engineer, Far East Army and Air Force Motion Picture Service, was honored by the Motion Picture Engineering Society of Japan, Inc., for his development of the 35mm pushbutton semiautomatic Dual Projector Controller.

Presentation of a bronze plaque and Certificate of Award in recognition of his contribution to Japan's technical advancement was made at a general meeting of the Society in Marunouchi Hall, Tokyo, by Rin Masutani, Director of the Society. Mr. Haines is the first foreigner ever to receive the Society's annual award.

The Dual Projector Controller, designed by Mr. Haines, was described in detail in the paper on "Military Theater Equipment Modernization" which appeared in the April issue of the SMPTE *Journal*.

Films for TV

"Only a short year ago, Hollywood studios were still holding themselves aloof from television. Today the two are dancing cheek to cheek. . . ." This was *Variety's* (March 28, 1956) interpretation of the upheaval in the entertainment world that occurred early in 1955 when major Hollywood studios released their film libraries to the TV networks.

Dancing cheek to cheek might be another interpretation of the controversial trend toward this form of cooperation between the two industries. Whether the cooperation is actual or only apparent is a question that has been asked in various ways by various interested parties.

"Who took whom?" was what Philip R. Ward asked in the *Financial Bulletin* (March 19, 1956).

The largest group of complaints came, naturally, from motion-picture exhibitors. But some of the loudest and most articulate howls of "folly" came from the established film stars such as Bette Davis, Joan Crawford, Humphrey Bogart, Clark Gable and many other who have passed their first youth. Some of these stars made their best pictures 15 or 20 years ago. At that time

they were younger and prettier. They feel that the competition is most unfair. They are competing with their younger, handsomer selves (which would be psychologically upsetting to anybody) and, what is worse, not getting a nickel for it.

A pointed question was asked by columnist Chester B. Bahn in the *Film Daily* (March 14, 1956). "What happens," he inquired, "to the old black-and-white films when the American television audience replaces its present sets with color receivers (as it most assuredly will within the next few years)?"

The story of the library deals is sprinkled with question marks. Coming as it did on the heels of "divorcement," the rush to unload film inventories through TV channels, while not a simple and direct "cause and result" situation, is certainly not unrelated to the event.

NBC expressed one point of view when, in a statement presented to the Senate Commerce Committee, March 26, it said, "The accumulated product in Hollywood's vaults — most of it musty and outdated — would hit television with the impact of a tidal wave. The American viewing public would literally drown in a celluloid sea." But the celluloid King Canute is not having any better luck than his predecessor.

By the last of June, an estimated total of 2,628 feature films had gone into TV distribution. Allied Artists had released 26 feature films; Columbia, 104 (through its subsidiary Screen Gems); Republic, 76; RKO, 740; Selznick, 10; 20th Century-Fox, 52; Warners, 850, and MGM, 770.

The latest Jack Horner to stick a thumb in the TV pie, M-G-M, announced on June 20 that its feature film library would be made available to TV on a rental basis.

The British publication, *Kinematograph Weekly*, reported on June 28, 1956: "Mr. Lou Chesler's bid of $50 million outright [to Loew's] made through the Ridgeway Corp. has been declined with thanks. National Telefilm's $34,500,000 offer for a 10-year lease has likewise been rejected. Instead Loew's is to be the first major Hollywood company to enter the TV industry as a network owner and operator, and will itself handle the television distribution of all its old films. . . ."

Mr. Chesler, a Canadian financier, controls the Warner library through PRM. His offer to M-G-M was contingent on the inclusion of *Gone With the Wind* in the deal, which Loew's refused.

With the exception of the sale of 1,450 shorts to UM & M TV Corp., Paramount, so far, has not released its library. This negative decision may be related to Paramount's reported interest in toll-TV through the International Telemeter Corp.

The full significance of the library deals cannot, of course, be thoroughly explored in this brief comment, and it would be only trifling to attempt to make any predictions on the basis of the presently available information.

One point of view was expressed quite clearly by a Subcommittee of the Senate Small Business Committee which said, "Film sales to TV cannot help but hurt the small exhibitors. The public is not going to be easily moved to go to the movies when classics can be seen in one's home free of charge."—*R.H.*

Obituaries

Philip E. Brigandi

Philip E. Brigandi, a Fellow of the Society and Manager of Ryder Sound Services, Inc., Hollywood, died July 23, 1956, as a result of injuries sustained in an automobile accident.

Mr. Brigandi served on the Board of Managers of the Pacific Coast Section in 1947–1948 and was Chairman of the Samuel L. Warner Memorial Award Committee in 1948. He was graduated from Cornell University in 1930 and joined the staff of Eastman Kodak Co., Rochester, N.Y., that same year. In 1933 he accepted a position with the Samuel Goldwyn Studio in Hollywood. In 1937 he became associated with Radio Corp. of America and in 1938 he joined RKO where he remained until 1952 when he became associated with Loren Ryder.

Scott Helt

Scott Helt, 49, patent administrator for Allen B. Du Mont Laboratories, Inc., and a member of the Society, died suddenly August 9, at his home, 370 First Ave, New York.

Born in Prichard, Alabama, he served as engineer for various radio and TV stations in the South and Midwest before joining Du Mont in 1944 as chief engineer. Mr. Helt was an instructor of a television course at Columbia University and was the author of numerous technical articles. He was the author of a book, *Practical Television Engineering*, and was regarded as an authority in the field of electrical engineering. He was a member of the Institute of Radio Engineers, American Institute of Electrical Engineers, American Association for the Advancement of Science and the Radio Society of Great Britain.

Beginning in 1951, Mr. Helt served on the SMPTE Papers Committee and he served on the Progress Committee during 1953–56.

section reports

The Southwest Section met July 13 in the Torch Restaurant, Dallas, Tex. This was the second meeting since the reorganization of this section. Fifty members and guests were present. Bruce Jamieson, Jamieson Film Co., Chairman of the Southwest Section, gave a demonstration of the SMPTE color test slides and a discussion of subject lighting contrasts for color films in color television. Jim Skinner, sound and projection engineer, Interstate Circuit, spoke on "The Installation of Todd-AO Projection Equipment."—*R. K. Keitz*, Secretary-Treasurer, c/o Keitz & Herndon, 4409 Belmont, Dallas, Tex.

The Northwest Section met July 24, 1956, at the KRON-TV Studio, San Francisco. The meeting was arranged in conjunction with the San Francisco Art Directors Club, the Northwest Section of the SMPTE, KRON-TV Eastman Kodak and Northern California TV stations and film producers. The meeting was attended by 85 members.

A symposium on Color Film for Television was held and a demonstration given of color film and slides over a TV system. Among the speakers were J. L. Berryhill, Chief Engineer, KRON-TV; William Wagner, Manager, Art Dept., KRON; Vaughn Shaner, Eastman Kodak Co., Hollywood; and several local film producers. Various types of color film and slides using Eastman Kodachrome, Eastman 5269 and Anscochrome were demonstrated through the KRON-TV system over a 7-mile microwave circuit. The speakers on the program were televised from the adjacent studio in live color and were seen on 21-in. color monitors.—*R. A. Isberg*, Secretary-Treasurer, Consulting Television Engineer, 2001 Barbara Dr., Palo Alto, Calif.

An international meeting of experts for the establishment of an international center of educational, scientific and cultural films for television was held at UNESCO House, Paris, June 13–20, 1956. A recommendation for the establishment of such a center was adopted at a meeting in Tangier, Sept. 19–30, 1955. The purpose of the Tangier meeting was to promote international cooperation between the motion-picture and television industries. Officers elected at the Paris meeting are: President, Henri Storck (Belgium); Vice-Presidents, Ivan Andreev (Union of Soviet Socialist Republics), Maurice B. Mitchell (United States of America), Paul Rotha (United Kingdom); Rapporteur, Henri Dieuzeide (France).

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1956 MEMBERSHIP DIRECTORY.

Active (M) Associate (A) Student (S)

This is the fifth list of New Members supplementing the April Journal, Part II, Directory.

Anderson, Donald Edward, TV Eng., KRON-TV. Mail: 1718 Valley View Ave., Belmont, Calif. (M)

Bier, David, Mot.-Pic. & TV Cameraman, Free-Lance, 1054 Manning Ave., Verdun, Que., Can. (A)

Butts, James H., Chief Eng., KOA-TV. Mail: 3074 Robin Way, Denver, Colo. (M)

Calvert, Orville Edward, TV Eng., American Broadcasting Co. Mail: 117 S. Kingston, San Mateo, Calif. (A)

Campbell, Robert Julian, Chief Elect. & Lighting Tech., Sam Goldwyn, 1041 N. Formosa, Los Angeles. (A)

Childs, Allen Edward, Animation Cameraman, Walt Disney Prod. Mail: 10106 Camarillo St., N. Hollywood. (A)

Cumming, William Kenneth, Chairman, TV-Radio Dept., Stephens Col., Columbia, Mo. (A)

Degenhardt, Fred M., Jr., Techn., Columbia Broadcasting System. Mail: 472 Brookside Pl., Cranford, N.J. (A)

Dome, John E., Director Audio-Visual Service, Miami Univ. Mail: 213 N. University, Oxford, Ohio. (M)

Drake, Kenneth F., Executive, UPA Pictures, Inc., 21 Upper Grosvenor St., London, Eng. (A)

Drege, Heinz A. K., Asst. Gen. Manager, Williams & Hill Ltd. Mail: 640 Lakeshore Ave., Hanlan's Point, Toronto, Ont., Can. (M)

Fleischer, Eugene B., Univ. So. Calif. Mail: 762 Eaton St., Elizabeth 2, N.J. (S)

Foist, Howard, Mot.-Pic. Lab. Techn., USAF. Mail: 3866 Utica Dr., Dayton 9, Ohio. (A)

Freericks, Bernard, Sound Mixer, 20th Century-Fox. Mail: 159 Ashdale Ave., Los Angeles 49. (M)

Futrell, Graham Kenneth, Photo., National Cotton Council of America, Box 9905, 1918 N. Parkway, Memphis, Tenn. (A)

Goldberg, Richard Jay, Research Chemist, Technicolor Motion Picture Corp., 2800 W. Olive, Burbank, Calif. (M)

Gooday, Robert Allan, TV Eng., Associated-Rediffusion Ltd. Mail: 82 Chelmsford Rd., Shenfield, Essex, Eng. (M)

Green, Leonard Arthur, Elect. Eng., United Church of Can. Mail: 45 Lockerbie St., Weston, Toronto 15, Ont., Can. (M)

Hart, Donald J., Color TV Eng., Smith, Kline & French Labs., Inc., 1530 Spring Garden St., Philadelphia. (M)

Jackson, A. Alan, Bus. Repr., IATSE Local 683, 6721 Melrose Ave., Hollywood 38. (A)

Kluehe, Harold Paul, Sound Techn., Free-Lance, 1406 Winnemac Ave., Chicago 40. (A)

Knipp, Harry, Jr., Cinemat., International Harvester Co. Mail: 1119 Community Dr., LaGrange Park, Ill. (A)

Kolisch, Emil, Consulting Eng., 170 E. 77 St., New York 21. (M)

MacRae, Elwin, TV Eng., ABC-KGO-TV. Mail: 408 Spruce St., Mill Valley, Calif. (A)

Mango, Frank, Projection Eng., IATSE Mot.-Pic. Projectionists. Mail: 1535 N. Las Palmas Ave., Hollywood 28. (M)

Mann, William J., Film Techn., Technicolor Motion Picture Corp. Mail: 14140 Remington St., Pacoima, Calif. (A)

Matsumoto, Tom, Cameraman, Free-Lance, 1618 S. King St., Honolulu, T.H. (A)

May, Paul, TV Eng., American Broadcasting Co. Mail: 430 Holly Ave., S. San Francisco. (A)

McCrummen, John R., Positive Color Control, Technicolor Motion Picture Corp. Mail: 14025 Hesby St., Sherman Oaks, Calif. (A)

Mirabello, S. J., Pres., Mirabello Enterprises, 41 Bustleton Pike, Feasterville, Pa. (M)

Payne, Ted Maurice, Cameraman, KSLA-TV. Mail: Apt. 807 Town House, Shreveport, La. (A)

Peterson, Gustav C., TV Lighting, Columbia Broadcasting System, Television City, Hollywood. (M)

Pfost, R. Fred, Elect. Eng., Ampex Corp. Mail: 1660 Lee Dr., Mountain View, Calif. (M)

Rodine, Ralph Nils, 443 S. Van Ness Ave., Los Angeles 5. (A)

Rosin, Seymour, Optical Designer, Scanoptic, Inc. Mail: 94 Laurel Dr., Massapequa Park, N.Y. (M)

Samuelson, Joseph M., Publisher, Miles-Samuelson, Inc., 21 E. 26 St., New York 10. (A)

Seitle, Rolf Albert, Eng., WTTW-TV. Mail: 5732 N. Kenmore, Chicago. (M)

Sengmueller, Fred, Sound Eng., Cinesound Films Ltd., 553 Rogers Rd., Toronto, Can. (A)

Smouse, Chuck Edward, Pres., Rainbow Island Productions, Ltd., 30 61 Kapiolani Blvd., Honolulu 14, T.H. (A)

Sprinkle, Melvin C., Eng., Ampex Corp. Mail: 395 Cuesta Dr., Los Altos, Calif. (M)

Tischoff, Tom Bradley, Major USAF. Mail: 1362 Photographic Flight, APO 328, San Francisco. (A)

Tyo, Gerald E., TV Eng., ABC, KGO-TV. Mail: 1848 Page St., Apt. 3A, San Francisco 17. (A)

Yoder, Gordon, Newsreel Cameraman, Telenews-News of the Day. Mail: 6055 Ridgecrest Rd., Dallas 31, Tex. (M)

Zamora, Felix Dising, Jr., Radio Eng., Philippine Govt. Mail: 3874 E. Vallejo St., Manila, P.I. (M)

Zavales, George T., Broadcast Eng., CBS-TV. Mail: 162-20 86 Rd., Jamaica 35, N.Y. (A)

books reviewed

The Public Arts

By Gilbert Seldes, Published (1956) by Simon P. Schuster, 630 Fifth Ave., New York 20. 303 pp. 5¼ × 8¼ in. Price $3.95.

The media of mass communication have resulted in the offering of program material for the first time in history to the public as a whole and not merely to a segment of it. This universal appeal implies universal obligations.

"The base of this new concept," says Gilbert Seldes, "is that, by their own nature, these arts are matters of public concern, subject to public opinion; that outside of law the public has sovereign rights over them, since these arts, no less than the institution of government, belong to the people." In order words, public art involves public responsibility. This is the nub of Seldes' book, and his somewhat discursive thread of analysis and reminiscences of the years of growth of motion pictures, radio and television, the "public arts," is finally tied off in the last chapter with an appeal for awareness by the public of its responsibility and the formulation of plans for better use of the media.

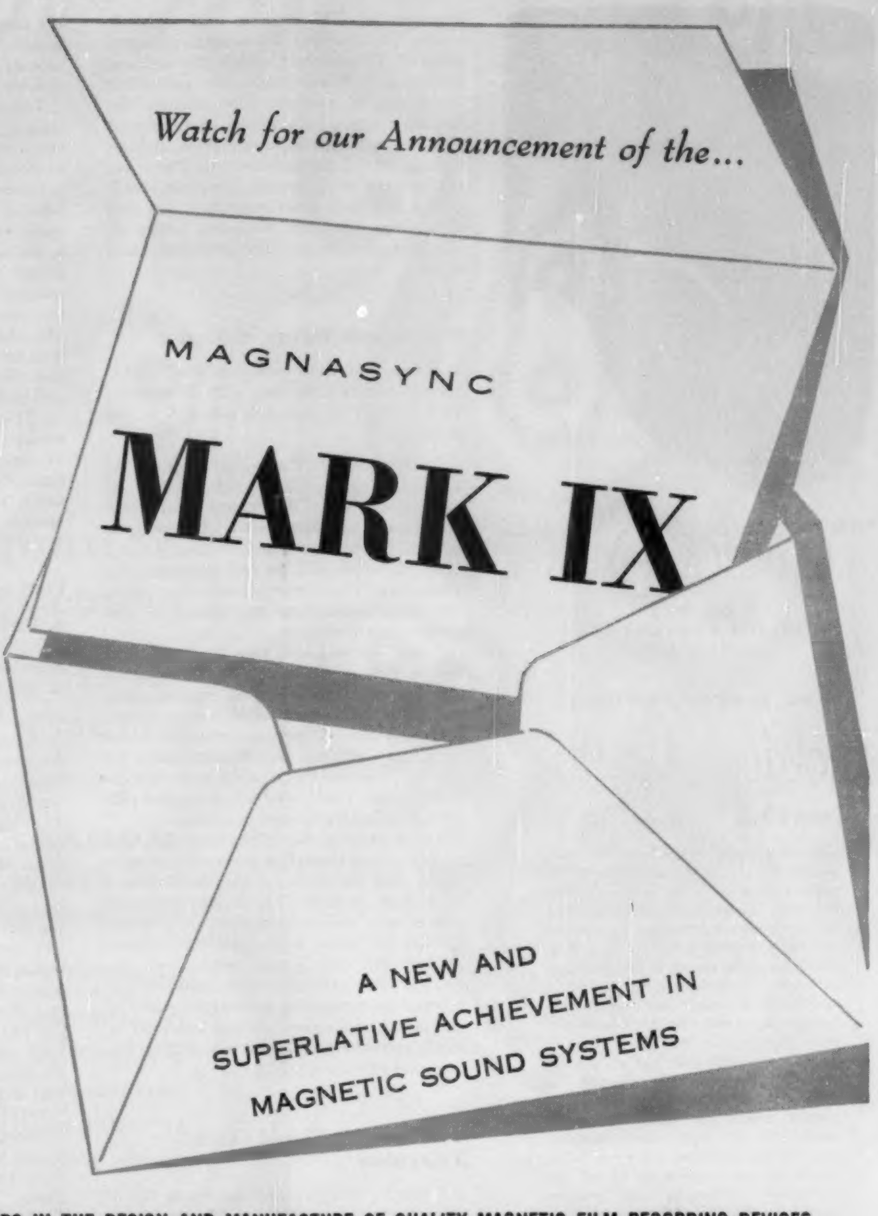
In degree of universality, the art of the motion picture has least claim of the three to qualify for Seldes' definition. Radio and television have been able to invade the American home and become a part of its daily life to a greater extent. But the chapters that describe the early triumphs and the progress of motion pictures through the various technological advances that have led up to the latest wide-screen processes indicate quite clearly Seldes' predilection for this, the "lovely art," which alone, at different times, has "given promise of becoming the single really new art of our time."

One chapter discusses and analyzes the growth of the animated film, with some shrewd criticism of Disney's achievements and a handsome bouquet to UPA. Another describes the new potentials afforded by the larger screen, whose success Seldes ascribes interestingly, not to the greater realism obtainable, but to its achievement of the imaginative quality of the trompe l'oeil painting, which is at the opposite pole from reality itself. "How in essence," he says, "do the new dimensions of the screen serve reality. They serve the imagination, and that is why we have the exciting prospect of experiencing, for the third time in our lives, a new art of the movies. Looking forward gratefully, we can afford to forget the blunders and bad taste and the stupidity that have attended the movies in the past."

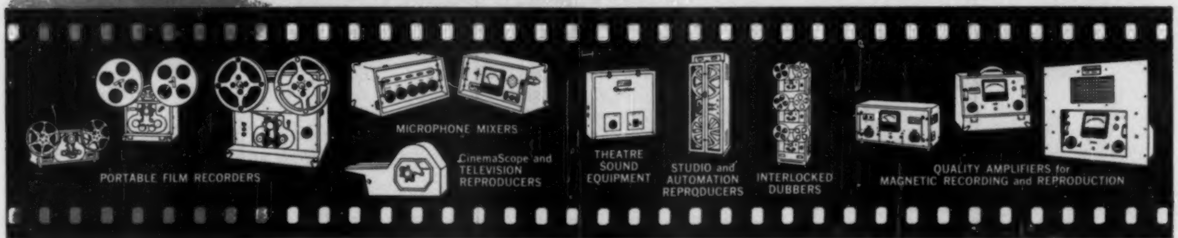
In his description of the growth of radio and television, Seldes discusses a great many programs and a great many personalities. Radio is passed over quite rapidly. Television is the subject of almost two-thirds of the book. True to his definition of the public art, he deals only with those popular programs having mass-entertainment appeal, and each of these he analyses and generally condemns with an effectiveness that is the greater because of the moderation of his expression. He is never supercilious, he does not indulge in invective; indeed less objective viewers might often find him too tolerant of what he occasionally refers to as the twaddle put out by the broadcasters. But his careful analysis of the mechanics and motivations of network programming is calculated to create the awareness of the need for improvement which he points to in his conclusion.

How the public obligation to improve the public arts is to be achieved Seldes does not presume to say. But this book makes a major contribution towards the first requisite — making the public aware of the issues and of its obligation.—*D.C.*

The 23rd semiannual edition of ***Television Factbook*** **is available from Television Digest, Wyatt Building, Washington 5, D.C. Priced at $4.50, the 456-page directory includes a 43 × 29 in. wall map showing**



INTERNATIONAL LEADERS IN THE DESIGN AND MANUFACTURE OF QUALITY MAGNETIC FILM RECORDING DEVICES



MAGNASYNC MANUFACTURING CO., Ltd., 5546 Satsuma Ave., North Hollywood 2, California

MAGNASYNC

Magnaphonic SOUND SYSTEM

DEALERS

NEW YORK—Camera Equipment Co., 1600 Broadway, New York 19. JUdson 6-1420. Cable Address CINEQUIP.

CHICAGO—Zenith Cinema Service, Inc., 3252 Foster Ave., Chicago 25, Ill. IRving 8-2104.

SAN FRANCISCO—Brooks Camera Co., 45 Kearney St., San Francisco, Calif. EXbrook 2-7348.

CANADA—Alex L. Clark, Ltd., 3745 Bloor St., Toronto 18, Ontario. BElmont 1-3303.

locations of TV stations and network routes. The *Factbook* also contains an international TV directory which lists stations, receivers, technical standards and other items for all nations. One section describes community antenna systems and lists 480 such systems in operation with an average of 912 subscribers each. There are also directories of networks, program syndicators, TV and radio manufacturers and electronics labs; and statistical tables on TV time sales, set and tube production and sales.

The Human Figure in Motion

By Eadweard Muybridge. Published (1955) Dover Publications, Inc., 920 Broadway, York 10. 215 pp. incl. 195 plates. 8 × 10¾ in. $10.00.

The name of Muybridge piques the interest of present-day photographers of motion who have seen many reproduced examples of his photographs of animals in motion. Muybridge is also of great interest from historical and general photographic viewpoints. The 8-page introduction about him and introducing the plates of this volume is informative.

Today's artists and animators will find here a rich reference on the posturing of the human figure — man, woman and child. After experimenting with and improving on his multiple-camera technique in the 1870's in California and Pennsylvania, by 1881 he was visiting France and enlightening artists there with his projected pictures of animals and men in motion.

Muybridge was one of the early few who in their efforts to analyze motion by photography laid the basis for the development of motion pictures. *The Human Figure in Motion* is a well-done reprint of a major portion of what was apparently Muybridge's last and largest publication. Although there have been many editions and reprintings, presenting various selections of the plates, old copies are not common or easily accessible and so this new edition is a valuable reference.—*V.A.*

Teaching by Closed Circuit Television

Published (1956) by The American Council on Education, 1785 Massachusetts Ave., N.W., Washington 6, D.C. 66 pp. Paperbound. 6 × 9 in. Price $1.00.

The book reports on a conference held Feb. 26–28, 1956 at the State University of Iowa. The conference was sponsored jointly by the University and the Committee on Television of the American Council on Education. Participating were 93 persons from 55 institutions and 16 organizations, including administrators, teachers and television technicians. Reports were heard from four experimental centers, State University of Iowa, Pennsylvania State University, New York University and Stephens College.

In his introductory remarks, Carroll V. Newsom, Conference Chairman said, "Our primary concern in educational TV must be the quality of the people working in the medium. It is not a place for the stodgy, the conventional, for people who are unable to look at problems in this new light. We need people with imagination. Educational television is new. It is expensive. One of our problems is to arouse public interest so the costs can be met."

The overall impression given by the report is that, generally speaking, the conferees agreed on the advantages of TV-teaching, but with certain reservations.

Dewey B. Stuitt, Dean of the College of Liberal Arts summed up the ideas of many educators when he said "We face a genuine problem finding enough competent teachers in the years ahead. This method will permit us to distribute a good instructor among many students and to get him closer to those students than the lecture method permits. We do not know what the effect of this will be on students who will be in a purely spectator or listener role. . . . Television is a good method depending on how much you believe in the merits of discussion over lecture, how important student-instructor intimacy is, and how much you want to distribute a first-class teacher throughout a series of classrooms.

Film and Cinema Statistics

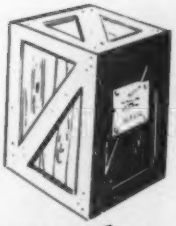
A UNESCO publication available in the U.S. from Columbia University Press, 2960 Broadway, New York 27. 111 pp. 8½ × 11 in. Price 50 cents.

The motion-picture industry is poorly documented and available statistics are frequently unreliable, although the yearly turnover is estimated at $4 billion and world-wide attendance at 10 billion persons. The aim of the UNESCO report is to evaluate existing statistics in certain selected areas of the industry and to make suggestions for the adoption of uniform standards throughout the world for the reporting and interpreting of motion-picture statistics.

This report covers production and importation of films, facilities for film exhibition and box office receipts. It was found that one of the greatest hindrances to interpreting reports from various countries was the lack of standardized terminology. For example, the definition of "feature" film and the distinctions between "long" and "short" film vary widely from country to country. Thirteen different standards were found to be used in 23 countries to differentiate between "long" and "short" films.

One section of the carefully documented report contains suggestions for standardizing international statistics and offers a detailed scheme of concepts and definitions. A résumé of this section is repeated in French and in Spanish.—*R.H.*

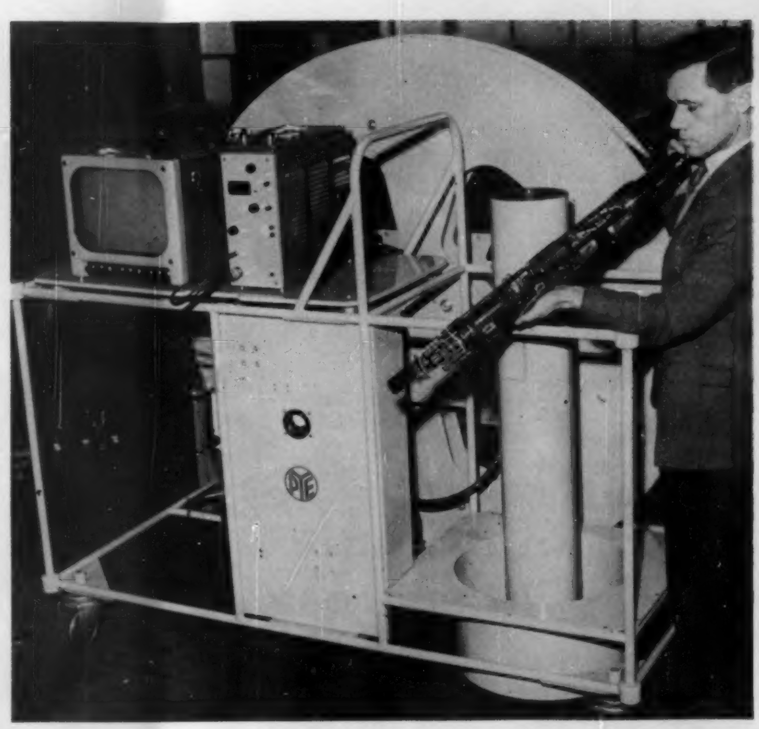
The 1956 edition of the *Radio and Television Bibliography*, issued each year by the Office of Education of the U.S. Dept. of Health, Education and Welfare, is available from the Department or the Superintendent of Documents, Washington, 25, D.C. (price, 25 cents). The bibliography contains, for the most part, titles of books on the historical, philosophical and sociological aspects of the media, vocational training and general interest. It does, however, contain a listing of 65 books dealing with engineering and technical developments.



new products

(and developments)

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products or services.



A camera designed by Pye Ltd. for the United Kingdom Atomic Energy Authority is used to view the interior of an atomic reactor when the degree of nuclear radiation makes direct inspection impossible. A young mechanical engineer, W. L. Cruickshank, worked for 18 months on the mechanical engineering problems involved in the development of this Atomic Age camera.

The design is based on that of well-established equipment used for normal industrial applications, employing only valves and components of standard types which are currently available. The chain comprises a camera head unit Type 2035 and a control unit Type 2324.

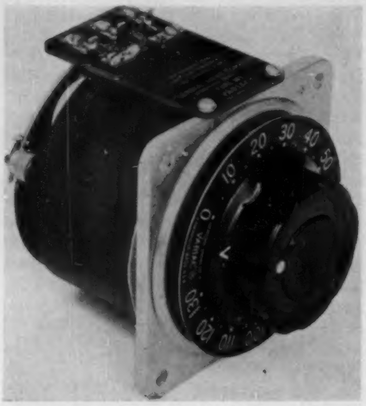
The camera head unit is fitted within a cylindrical stainless steel tube, having an outside diameter of 3½ in. and is approximately 40 in. in length, including end couplings. All metal parts are of stainless steel or elektron and all electrical parts are "potted" in order that the unit may be decontaminated after being exposed to radiation.

As the camera may be used in temperatures up to 200 C, provision is made for the application of a coolant such as carbon dioxide, to keep the temperature within the unit below 50 C. The coolant is applied with a flexible hose which forms a loose-fitting sheath over the interconnecting cable.

A single-lens optical system is employed, incorporating a viewing lens with a focal length of 1½ in. and a viewing angle of 21°. A 72-w 4-lamp lighting system is used for scene illumination and an adjustable mirror provides for sideways viewing. The lens, lamps and mirror are mounted together in a turret assembly which also incorporates a solenoid for controlling the position of the mirror and a motor-driven mechanism by which the whole assembly can be rotated. A photoconductive pick-up tube, the Staticon Type 932, made by Cathodeon Ltd., is used to convert the optical image to an electrical signal. This signal is amplified by a single-stage preamplifier before being passed to the control unit via the interconnecting cable.

The control unit is housed within a rectangular metal case, 14 in. in height, 6½ in. in length and is fitted with a carrying handle. The side panels are secured by quick-release fasteners and are easily detached to give access to the components and preset controls located within the case. Incorporating all the essential requirements for the control of the picture signal produced by the camera, the unit may be located with a picture monitor to form the control center of the installation and permit the camera to be unattended.

Two lamps mounted on the top of the unit provide for visual monitoring of the operating temperature within the camera head unit. The lamps are colored green and red. The green lamp is "on" when the operating temperature is below the safe maximum level of 50 C, and the red lamp gives warning when the temperature rises above that level.

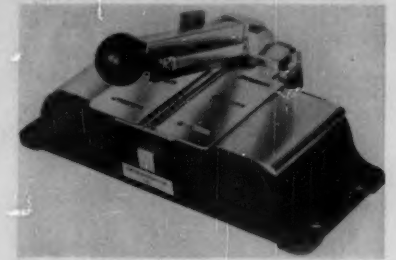


The Type W5 Variac autotransformer, manufactured by General Radio Co., 257 Massachusetts Ave. Cambridge 39, Mass., offers a number of new features including Underwriters Laboratories listing, military ruggedization and counterbalanced rotating parts. Two cased models, both totally enclosed, are included in the new line One model, Type W5M, is intended for wall or panel mounting and is provided with conduit knockouts. Type W5MT is bench and portable model complete with input cord, switch and output plug. This model is also available with the new NEMA 3-wire output receptacle and plug (Type W5MT3). Two-gang and three-gang assemblies of both 115-v and 230-v Variacs are available in enclosed or open models.

The new W2 Variacs are similar in general construction to the W5 line except that current and kva ratings are 40% of the Type W5, and their dimensions and weight are considerably less. The basic W2 model has an increased rating of 20% above the Type V-2, which it supersedes.

The annual Magnasync Sound Safari left August 1 for a tour of the country to demonstrate latest developments in sound equipment to producers. Since 1953, the Magnasync Mfg. Co., 5546 Satsuma Ave., North Hollywood, has made a yearly practice of carrying sound equipment to producers throughout the United States so that tests may be made in the producers' own studios. In the larger cities meetings are arranged where techniques and equipment may be discussed.

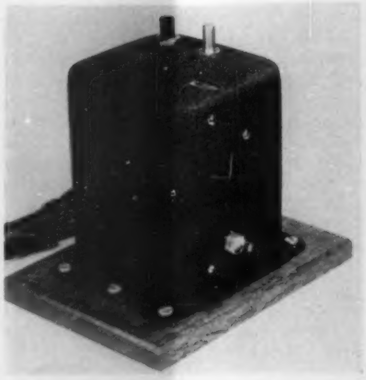
Circle Film Laboratories, Inc., 33 W. 60 St., New York 23, has been purchased by Fred Todaro and the firm name has been changed to Criterion Film Laboratories. Todaro joined the company about a year ago as plant superintendent. He announced that plans for the newly named company included additional technical personnel and a wider range of activities.



The Opto Multi-Splicer, a product of the Photographic Analysis Co., 100 Rock Hill Rd., Clifton, N.J., splices either 35mm or 70mm film and with a slight modification will splice any size film between 35mm and 70mm. The cutting blades and emulsion scraper are chrome plated over hardened tool steel. Guide pins are precision machined and located within 0.0005 in. The splicer is designed for the operator to choose the location of his splice between frames by a screwdriver adjustment. A positioning lever locates the film in the exact place for cementing after cutting.

The Opto Serial Marker, a product of the Photographic Analysis Co., 100 Rock Hill Rd., Clifton, N.J., is a new equipment for recording a 5-digit serial number on film or photographic paper before processing.

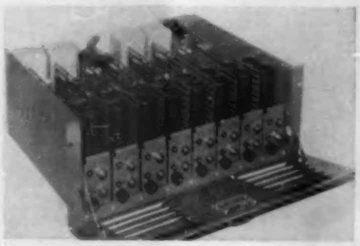
The serial number measures only $\frac{1}{16} \times \frac{1}{8}$ in. so that the picture area is not affected. There are three steps in the operation of



the marker. First, the film is pressed against the window with the right thumb; second, the light control button at the upper left corner of the marker is held down for from one to five seconds with the lefthand; and third, the numbers are advanced singly by pressing the advance button at the right of the light button. The counter is reset by rotating the side knob. Light is supplied by a 3-w bulb. Current is 115-v, a-c or d-c.

A new Swivel Ball Joint attachment for tripods that allows the camera to be leveled to the right horizontal position, although the ground or tripod legs are not straight is a product of Cinekad Engineering Co., 500 W. 52 St., New York 19. The Swivel Ball can be easily placed between head and tripod body and has enough tightening strength to hold the biggest and heaviest motion-picture cameras. It is made of light weight aluminum and weighs 4 lb. It is priced at $50.00, f.o.b. New York.

The Berkshire Labstrobe, Model 18A, is a small, light stroboscope unit, giving 60 brief flashes of light per second when connected to an ordinary 60-cycle power line. Pulses are all in the same direction, therefor only one of the D-shaped electrodes glows. Sixty short pulses of light per second are generated instead of the usual 120 relatively long pulses of the ordinary neon lamp. The Labstrobe is priced at $9.95. Descriptive literature may be obtained from Berkshire Laboratories, Greenville, N.H., by requesting Catalog Sheet No. 18A-1.

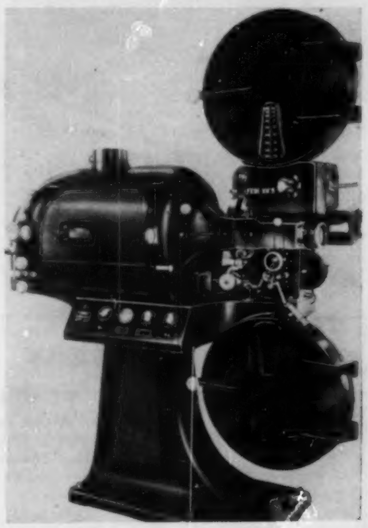


A new Pulse Distribution Amplifier, reported to provide greater output voltage, more rapid pulse rise and more complete pulse clipping, is available from the manufacturer, General Precision Laboratory Inc., Pleasantville, N.Y. It is designed to meet the sync distribution requirements of multiple camera chain installations in broadcast television operations and can be used for both color and monochrome signals.

Known as Model PA-1004, the amplifier consists of a compact, plug-in chassis containing three stages of amplification. The basic unit plugs into its own frame (Model PA-1005) which mounts on a conventional width rack and holds a total of eight amplifier units. Each unit is designed for easy removal and replacement or maintenance.

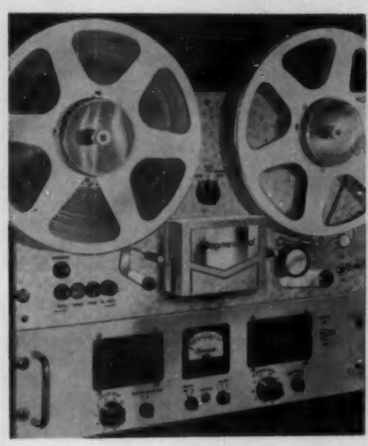
GPL has also announced a new Video Distribution Amplifier, Model PA-1002.

The Victor Animatograph Corp. of Davenport, Iowa, has affiliated with the Kalart Co., Inc., of Plainville, Conn. Manufacturing of Victor 16mm sound projectors and all other Victor products will be transferred to the Kalart plant. Management headquarters and service and training facilities will continue at the Davenport address. The New York and Chicago branch offices will continue in their present location. There will be no change in name, personnel, or company policies.



Complete 35mm projector installations are manufactured in Italy by the firm of Fedi, 6 Via S. Gregorio, Milan. The Fedi XII S projector is equipped for optical and magnetic sound reproduction and can be used for CinemaScope, VistaVision or Perspecta Sound. With the addition of a special synchronizing mechanism, which is also available from Fedi, this model can be used in pairs for 3-D projection. The 130 WM 4-channel amplifier is designed for use with this projector. The Fedi XI projector is also equipped for optical and magnetic sound. The arclamp on the XII S has a 420-mm mirror; on the XI the arclamp mirror is 350mm. Both arclamp assemblies are obtainable separately from this company.

A flame-resistant, vinyl-coated fabric for draperies to darken window areas in schoolrooms and auditoriums, primarily for audio-visual work, has been developed by E. I. du Pont de Nemours & Co., Wilmington, Del., in its laboratory at Newburgh, N.Y. The drapery was designed to meet certain specifications such as permanent flame resistance and resistance to deterioration, discoloration, shrinking, stretching or tackiness.



A rack-mount tape recorder amplifier, the P-60-ACX, has been announced by Magnecord, Inc., Chicago. Designed for professional use to simplify editing and cuing operations, the recorder conforms to NARTB standards. It is powered by a 3-motor direct drive with two-speed hysteresis synchronous drive motor and operates from pushbutton controls. The recorder may be used in either vertical or horizontal operation. It features solenoid brake control to prevent tape spillage deep slot loading for easier threading, high impedance playback head and low impedance recording head. A throwover switch is available to enable the operator to record continuously by setting up two machines, with a single amplifier.

The controls and motor of the unit's transport mechanism are on separate assemblies, access to each of which is through loosening four bolts. Brakes can be serviced from the front of the transport. It is priced at $680.00, and with carrying case sells for $765.00.

High-speed Anscochrome 16mm motion-picture film is now being sold without the cost of processing included in the price of the film. The change was made in response to requests from government agencies and industrial organizations engaged in confidential work. If a film is to remain top secret, it must be processed in government laboratories or private laboratories where maximum security measures are possible.

For non-confidential work, Ansco maintains its two processing laboratories at 2299 Vaux Hall Road, Union, N.J., and 247–259 East Ontario St., Chicago. Films for the two standard speeds, Exposure Index 32 or Exposure Index 125 can be processed at either laboratory.

The Hollywood Film Co., 956 Seward St., Hollywood 38, has issued a new catalogue of 16mm and 35mm precision editing equipment including reels, cans and shipping cases. The catalogue lists film editors' needs from A (acetone) to V (velvet and viewers). It will be sent without charge if the request is made on your letterhead.

Another item from the same firm reports the opening of a New York office at 630 9th Ave. in the Film Center Building. Showroom and warehouse facilities are available at this location, however, mail orders should continue to be sent to the main office in Hollywood. The new office is under the supervision of Sheldon Kaplan.

employment service

These notices are published for the service of the membership and the field. They are inserted three months, at no charge to the member. The Society's address cannot be used for replies.

Positions Wanted

Experienced photographer seeks job with industrial firm. Write to: James W. Chipman, Fennimore, Wisconsin.

Television Program Assistant. College Graduate, B.S. Business Administration. October graduate from SRT-T.V. School, Programming & Production. Background in music, including both radio and television experience. Also, five years of summer dramatics with both acting and direction experience. Directed fifteen closed-circuit shows and have thorough skill with RCA cameras (black-and-white & color), RCA boom, switching units, etc. Available October 15, 1956. Morton Eisgrau, 63 Fremont St., Harrison, N.Y.

Television Studio Floorman. Graduate from T.V. Workshop. Anthony Guiffre, 228 East 112th Street, New York. TR 6-0170.

Audio-Visual Technician. Young man, married, recently separated from service, seeks position as an audio or visual engineer. Background in electronics. A.A.S. in Electrical Technology, First Class Radio Telephone License. Served as Broadcast Engineer with the Armed Forces Radio Service. Desires a position with organization in the New York City area. Complete résumé upon request. Sheldon Pivnik, 2129 East 14 St., Brooklyn 29, N. Y.

Television Film Director-Motion Picture Cameraman-Film Editor. Over five years experience in television film operations, now employed, desires connection with organization active in film production. Owns own motion-picture camera and film editing equipment. Active member SMPTE. Single with car, free to travel. Best references. Require thirty days notice to present employer. Frank E. Sherry, 1505 North Summit Ave., Tyler, Texas. Tel. 2-6132.

Technical Film Sales Consultant. Thorough grasp of production technique;. cinematography, recording, editing, animation, lab procedure; twelve years' experience, technical, sales and administrative; former independent producer; versatile, mature, disciplined, 35 years; available 7-31-56. What have you to exploit "rare bird" potential? Write: CMC, c/o Volksoff, 172 West 4th St., New York 14.

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Kodachrome Laboratory Manager. Berkey Photo Service, largest photofinisher for color and black-and-white in the U.S., requires services of man capable of taking full responsibility for installation of complete processing equipment for 35mm still and 8mm and 16mm cine films, and for supervision of all personnel. Must have knowledge and experience for all necessary controls. Position will be open in early Fall of 1956. Five-figure salary to start. Bright future. Please write full details of your experience and references. Replies will be kept confidential. Write to: B. Berkey, Berkey Photo Service, 77 E. 13 St., New York.

Writer-Director for technical and engineering films dealing with intercontinental Navaho missile and associated systems and equipment. College graduate with film production training preferred. Three years' experience writing and/or directing factual industrial films required. Good salary and company benefits. Work in Los Angeles and Florida. Write: E. F. Brunetti, Engineering Personnel, North American Aviation, Inc., Downey, Calif.

Cameramen and Film Editors for technical and engineering films dealing with intercontinental Navaho missile and associated systems and equipment. Three years' experience for cameramen and two years' experience for film editors (male or female) required. Good salary and company benefits. Write: E.F. Brunetti, Engineering Personnel, North American Aviation, Inc.,Downey, Calif.

Physicists, Photo-Optics. For research and development on tasks in metric photography, infrared systems, visibility and related instruments. Location: Northwest Florida or Chicago, Ill. Positions at junior and senior levels. Address replies to: Chicago Midway Laboratories of the University of Chicago, Eglin Air Force Base, Fla.

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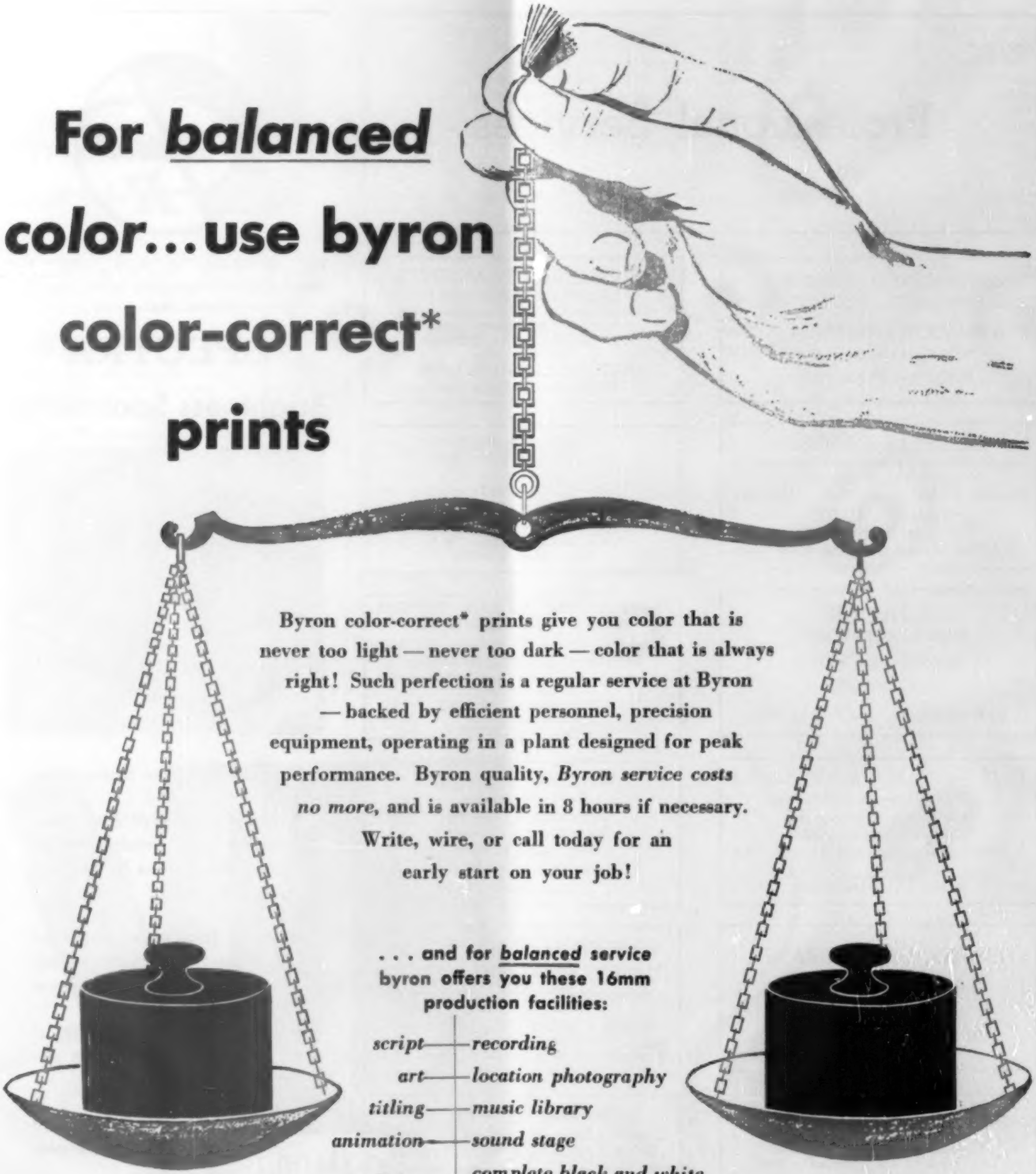

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News Columns

Advertisers

Meeting Calendar

American Society for Testing Materials, Second Pacific Area National Meeting, Sept. 17–21, Hotel Statler, Los Angeles.
Eleventh Annual International Instrument-Automation Conference and Exhibit, ISA, Sept. 17–21, New York Coliseum, New York.
Theater Owners of America, Inc., Annual Convention, Sept. 19–25, Coliseum, New York.
Industrial Electronics Conference IRE, AIEE, Sept. 24–25, Hotel Manager, Cleveland, Ohio.
Audio Engineering Society, Annual Convention, Sept. 26–29, New York Trade Show Bldg., New York.
New York High Fidelity Show, Sept. 27–30, New York Trade Show Bldg., New York.
Canadian IRE Convention and Expansion, Oct. 1–3, Automotive Bldg., Exhibition Park, Toronto, Ont., Canada.
National Electronics Conference, Inc., 12th Annual Conference, Oct. 1–3, Hotel Sherman, Chicago.
National Association of Education Broadcasters, Oct. 16–18, Atlanta.
80th Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 8–12, Ambassador Hotel, Los Angeles.
Optical Society of America, Oct. 18–20, Lake Placid Club, Essex County, N. Y.
American Standards Association, Annual Meeting, Oct. 22–24, Hotel Roosevelt, New York.
Ninth Annual Conference on Electrical Techniques in Medicine and Biology, Nov. 7–9, Governor Clinton Hotel, New York.
National Electrical Manufacturers Association, Nov. 12–16, Traymore Hotel, Atlantic City, N. J.
Acoustical Society of America, Nov. 15–17, Los Angeles.
3rd National Symposium on Reliability and Quality Control in Electronics, Jan. 14–16, 1957, Hotel Statler, Washington, D. C.
American Institute of Electrical Engineers, Winter General Meeting, Jan. 21–25, 1957, Hotel Statler, New York.
American Institute of Electrical Engineers, Summer General Meeting, June 24–28, 1957, Montreal, Que.
Radio Engineering Show and IRE National Convention, Mar. 18–21, 1957, New York Coliseum, New York
American Institute of Chemical Engineers, Dec. 9–12, Hotel Statler, Boston, Mass.
81st Semiannual Convention of the SMPTE, including Equipment Exhibit, Apr. 29-May 3, 1957, Shoreham Hotel, Washington, D. C.
82nd Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 4-9, 1957, Philadelphia-Sheraton, Philadelphia.
83rd Semiannual Convention of the SMPTE, including Equipment Exhibit, April 21-26, 1958, Ambassador Hotel, Los Angeles.
84th Semiannual Convention of the SMPTE, Oct. 20-24, 1958, Sheraton-Cadillac, Detroit.
85th Semiannual Convention of the SMPTE, including International Equipment Exhibit, May 4-8, 1959, Fontainebleau, Miami Beach.
86th Semiannual Convention of the SMPTE, including Equipment Exhibit, Oct. 6-10, 1959, Hotel Statler, New York.

SMPTE Officers and Committees: The rosters of the Officers of the Society, its Sections, Subsections and Chapters, and of the Committee Chairmen and Members were published in the April 1956 Journal.

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